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JOINT HIGHWAY RESEARCH PROJECT

JHRP-75-22

IMPROVING EMBANKMENT DESIGN AND PERFORMANCE: PREDICTION OF AS-COMPACTED FIELD STRENGTH BY LABORATORY SIMULATION

John L. Peterson

PURDUE UNIVERSITY

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Interim Report

IMPROVING EMBANKMENT DESIGN AND PERFORMANCE:
PREDICTION OF AS-COMPACTED FIELD STRENGTH BY LABORATORY SIMULATION

TO: J. F. McLaughlin, Director
Joint Highway Research Project

December 1, 1975

Project: C-36-5M

FROM: H. L. Michael, Associate Director
Joint Highway Research Project

File: 6-6-13

The attached report titled "Improving Embankment Design and Performance: Prediction of As-Compacted Field Strength by Laboratory Simulation" has been authored by Mr. John L. Peterson, Graduate Instructor on our staff under the direction of Professors A. G. Altschaeffl and C. W. Lovell. The report covers a laboratory simulation phase of the Study.

One purpose of the study is to determine the variability and source of variability of the strength of field compacted embankments and to relate this characteristic to functional relationships developed in the laboratory. From published data and from field and laboratory data generated by project personnel, analysis indicated differences in strength might be most readily explained by variations in moisture content. This, however, was not proven conclusively due to the statistical nature of the data. The report also includes initial development of a prediction technique for field strength. The results appear promising and verification is continuing.

This Report is submitted as partial fulfillment of the objectives of this Study. After acceptance by the JHRP Board it will be forwarded to ISHC and FHWA for their review, comment and similar acceptance.

Respectfully submitted,

Harold L. Michael

Harold L. Michael
Associate Director

HLM:sas

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by

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Project No.: C-36-5M

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Conducted by

Joint Highway Research Project
Engineering Experiment Station
Purdue University

in cooperation with the

Indiana State Highway Commission

and the

U.S. Department of Transportation
Federal Highway Administration

The contents of this report reflect the views of the author who is responsible for the facts and the accuracy of the data presented herein. The contents do not necessarily reflect the official views or policies of the Federal Highway Administration. This report does not constitute a standard, specification, or regulation.

Purdue University
West Lafayette, Indiana
December 1, 1975

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15. Supplementary Notes Conducted in cooperation with the U.S. Department of Transportation Federal Highway Administration. Research Study titled "Improving Embankment Design and Performance".

16. Abstract Three sources of soil compaction data were sought; published works, Indiana State Highway Commission construction files, and field and laboratory data generated by project personnel.

The published and construction file data were categorized and statistical analysis of variance and regression techniques were used on suitable sets for evaluation. The expected trends in general were noted; however, due to the statistical characteristics of these data firm conclusions could not be made as to what are the sources of the exhibited variability and behavior of the compacted soil.

Field data were obtained by sampling a local highway embankment. From bag samples taken at the fill, laboratory compaction tests were used to generate additional data. The field and laboratory data yielded an encouraging relationship between field and laboratory as-compacted compressive strength for the soil. Molding water content appeared as the dominant factor in the strength prediction model.

Additional investigation is continuing. A recommendation was made to develop a test embankment for future field investigation; this should allow isolation of the compaction variables which are most influential in producing the variability observed in the field data.

17. Key Words	18. Distribution Statement
Compaction, compressive strength; field; laboratory; soil; soil property variability	

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Highlight Summary

Improving Embankment Design and Performance: Prediction of As-compacted Field Strength by Laboratory Simulation

One aim of the project is to determine the variability and source of variability of the strength of the field compacted mass and to relate this to the functional relationships developed in the laboratory. With such a relationship, the designer can more efficiently predict the behavior of the compacted embankment; this could produce a more economical and safe design.

Three sources of information were investigated during this study; published data, Indiana State Highway Commission construction file data, and field and laboratory data generated by project personnel. From the first two sources it was hoped that sufficient replicate data could be obtained that would provide a base for a statistical evaluation of variability and sources of variability of the field compacted product. With this base further analysis would be continued into the data which the project would generate. Using analysis of variance (ANOVA) and regression techniques, the published data yielded the expected trends for the encountered types of compaction. The construction file data did not. Due to the small sample size in the sets of published data and the non-homogeneity of the construction file data no conclusive inferences were obtained. These and other data sources are being further investigated.

Field samples were taken from a highway embankment concurrently with the normal quality control testing. At these locations bag samples were taken for laboratory use. Those locations having similar soil types were then used in the analysis.

An ANOVA was made across locations and all three variables; molding water content, dry density, and unconfined compressive strength, were significantly different. The differences in strength appeared to be explained more readily by the variations in moisture content but this could not be proven conclusively due to the statistical nature of the data.

The laboratory processes used were the Standard Procter and Harvard Miniature compaction tests. Unconfined compression strengths were obtained from these specimens. Regressions were performed with relatively close-fitting functional relationships obtained. The Standard Procter relationship was then used to predict field strength using the associated field density and moisture contents data.

Based on these predictions a relationship was then formulated for the observed field strength versus predicted strength. This prediction appears quite reasonable with the majority of predicted determinations slightly less in values than the observed field points.

Further work is currently under way to verify these initial findings. A recommendation for a test pad to be used to isolate sources of variabilities for the field compaction was made.

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INTRODUCTION

This report is the initial report on the first portion of a larger research study dealing with the variability in the results of soil compaction. This study is motivated by the realization that the compaction process produces a soil mass having a variability in its characteristics. Thus, there is induced a variability in its behavior properties. Because the engineer is forced to "live with" this variability in his analyses, a better understanding of the variability (its magnitudes and courses) could help the engineer in his predictions of performance of the soil mass. This study postulates that there is a functional relationship between as-compacted soil strength and soil compaction variables different aspects of which have been reported by Hodek (1) and Sisiliano (2), among others. A relationship, then, should exist for field compaction, as well as for laboratory compaction. If this is so, a correlation between the two should be possible. Hence, one could predict field parameters from laboratory data using appropriate statistical techniques. An extension of predictability might then also be possible to other in-service behavior characteristics.

In order to identify relationships involving variability of the as-compacted strength and the variability of as-compacted density and water content, data were obtained from published and unpublished sources. Additional data were obtained by field sampling and testing on an Indiana State Highway Commission (ISHC) construction project. A laboratory testing program on soil taken from the field project was

conducted concurrently. Statistical methods were used to evaluate the data. The design of the testing program and testing procedures used are described in Part I. The data which have been obtained to date and their analysis are presented in Part II.

The study has as its ultimate goals (a) to determine the effects of the variability of the compaction process upon the quality of predictability of the engineering behavior of the compacted Indiana soils, and (b) to further suggest what measures might be used if the degree of control of the behavior property needs to be more stringent. So far it appears that a reasonable correlation exists between laboratory as-compacted and field as-compacted strength; a framework has thus been created for a more comprehensive study of the field soil behavior properties and their predictability.

PART I DEVELOPMENT OF TESTING PROGRAM

PART I DEVELOPMENT OF TESTING PROGRAM

General

A compaction specification is written for the primary purpose of producing in the compacted mass the behavior intended by the designer. Within the specification are constraints by which the designer hopes to optimize the design parameters.

Natural soil materials and the compaction process are both inherently variable; when combined they tend to yield a non-uniform product. It is this non-uniform and variable nature of the product that must be assessed in the design of a safe and economical earth structure.

Historical Development

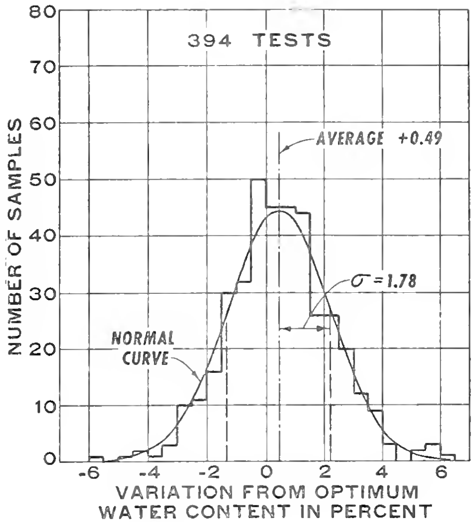
The process of compaction is a mechanical densification involving the reduction of air voids in an earthen material at a water content essentially unchanged during densification. The results of this process are dependent upon the interaction of several factors at the time of compactions. The principal factors (for most general field conditions) are soil type, moisture content of the soil, equipment type, equipment use, lift thickness, and temperature. The intent of this process is to produce an earthen product with the desired behavior characteristics. The achievement of a high unit weight is not the direct objective; however, due to past experience, unit weight has been used in a very empirical manner for suggesting a prediction of as-compacted and in-service behavior.

Patterns of behavior of compacted masses have been presented by Altschaeffl and Lovell (3), and by Seed and Chan (4), among others.

These studies show that the water content at the time of compaction (as it relates to the optimum water content for that type and energy of compaction) is the most important variable controlling the subsequent behavior of that compacted mass. Water content is much more important than is the soil density.

Other investigations have reported on the nature of the variability found in the field for as-compacted water content and unit weight. These statistical studies include those of Williamson (5), Shah and Adam (6), Turnbull et al (7), Hilf (8), and Sherman et al (9). The consensus of these field studies illustrate the concept that the unit weight and water content of the compacted mass vary about mean values in a manner which would be statistically be called a normal distribution. An example of such a distribution using data for a large embankment is shown in Figure 1. The magnitude of the spread of the values is a function of soil type, equipment, variation in water content of the soil used, and the uniformity of equipment application. It is impossible to remove this spread or variability from the compacted mass.

Furthermore, investigators have also reported on the variability which appears to be inherent in the test results for some of the properties used to measure behavior characteristics. The unconfined compressive strength was examined by Wu (10), Hooper and Butler (11), Ward et al (12), Wary (13) and Peck and Ried (14). Compressibility and the settlement problem were treated by Folagen et al (15) and by Cozzolini (16). Strength of the as-compacted product was discussed by Seed and Chan (4), Highter et al (17), and Holtz and Ellis (18).



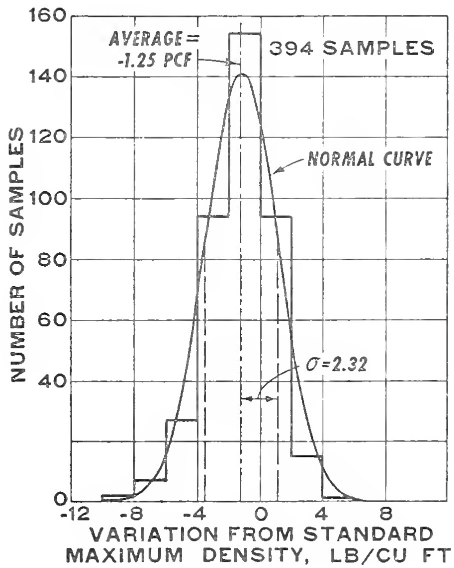


Figure 1. Variation From Optimum Water Content and Standard Maximum Density of an Impervious Fill (Turnbull et al (7)).

Figure 2 illustrates some test results which have been observed by Seed and Chan (19). These studies indicate that the test results vary just because an experimental testing operation was used to obtain them; this variation occurs even if seemingly replicate samples are used in exceedingly standardized testing. Some variability in the test results was implicitly attributed to the natural variability of the test specimens. The relative importance of the several factors in producing the variability was not addressed in any of the studies.

Although there has been a significant amount of work done, one important area has not been discussed. There has been no reasonable correlation developed on a statistical basis, between the laboratory test results and the field as-compacted and in-service test results. There has also been no examination made of the changes of in-service behavior in terms of the variability influence during the compaction process.

Description of Initial Stage of Study

This portion of the study intended to create a relationship for as-compacted strength and its variability as produced by the variability in unit weight and water content during compaction; this was to be done for both field and laboratory compaction for typical Indiana soils. Then, given this relationship between field and laboratory results, an effort would be made to see if the variability in strength could be reduced by more stringent control on the water content of the soil or on some other compaction variables. As a result it was hoped a prediction would be possible for field strength

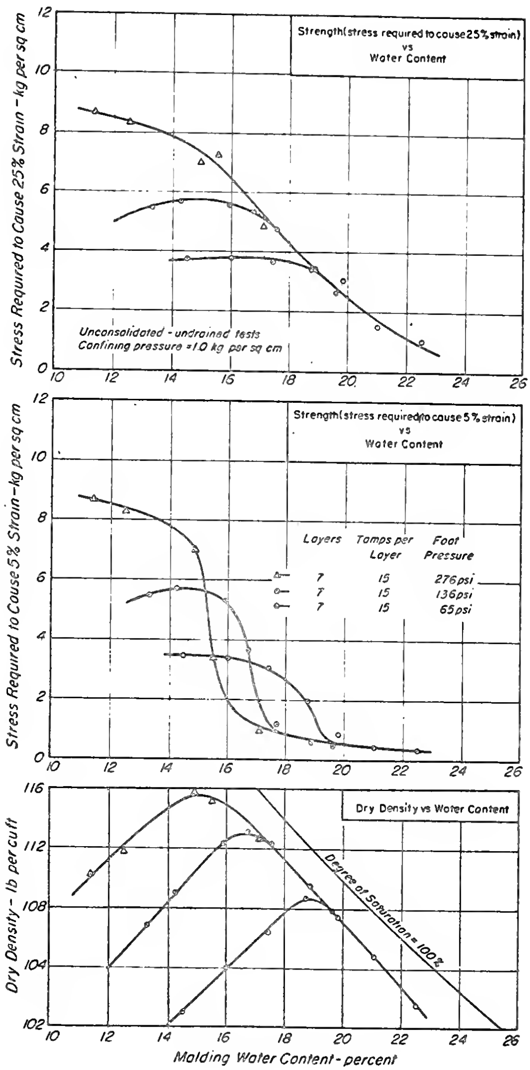


Figure 2. Dry Density and As Compacted Strength Versus Molding Water Content For Kneading Compaction of a Silty Clay (Seed and Chan (19)).

using laboratory data; in addition a semi-quantitative measure (at worst) might then be available for deciding the degree of compaction control that might be needed.

Description of Study

To identify the correlations and variabilities involved between field and laboratory compaction products, a list of items to be investigated was developed. These items were as follows:

1) For the available data on recent Indiana compaction projects determine if the variability and/or magnitude of unit weight and water content (or their interaction) is a significant function of some variable of the compaction process.

2) For a test embankment collect data and determine the following:

   a) Is the variability in unit weight and water content similar between testing locations and is this variability compatible with that determined from other local compaction projects?

   b) Is the variability in strength (as-compacted) a function of the variability of the magnitude of the compacted unit weight or water content?

   c) Can strength be predicted with confidence from unit weight and water content?

3. Using laboratory compaction processes on the same material used in item 2 above, generate compaction data and determine the following:

   a) Are strength variabilities the same as found in the field data?

b) Are laboratory test variabilities similar to the field?

c) Is the strength variability a significant function of unit weight and water content or their variabilities?

d) Can strength be predicted from unit weight and water content?

e) Does a functional correlation exists beween the field strength and the laboratory as-compacted strength?

To answer the items listed above this portion of the study was divided into three phases. An outline of each phase is given in the following paragraphs.

1) Published Data

A literature search was made to locate information on the compaction process and the variations experienced in the compacted product. Those items which involved soil types similar to those found in Indiana embankment construction works are then processed further. Compatible groups are treated statistically to determine trends of the variability of the compacted product. General trends from these data can help establish a larger confidence in the result of the ongoing field and laboratoring testing.

2) Unpublished Data

Data were obtained from recent Indiana State Highway Commission projects. These data were categorized. The trends suggested by the actual control data would be used to further extrapolate the correlation obtained by the third phase of this portion of the study.

3) Field and Laboratory Testing

A nearby Indiana State Highway Commission project was used to obtain compaction data, as well as bag samples for laboratory testing, fom an overpass embankment. Tube samples were taken to obtain unit weight, moisture content, and strength data of the as-compacted fill. From the bag soil samples laboratory compaction data were generated. The results of both processes were statistically analyzed and compared. Then a correlation was generated between the field and laboratory processes.

More detailed methodologies along with data results and conclusions are given in Part II of this report.

PART II DESCRIPTION OF STUDY PERFORMED AND DATA OBTAINED

PART II DESCRIPTION OF STUDY PERFORMED AND DATA OBTAINED

Available Published Data

Information was gathered from such various sources as U. S. Governmental agencies, domestic professional journals and foreign professional papers. The computerized information system, Transportation Research Information System (TRIS) was accessed to locate current research articles and reports of potential value in the literature search.

It was hoped that the data from many different sources would yield replicate field compaction-strength data. Unfortunately, virtually every source of data had something peculiar to that particular data set. Also, a large number of sources contain the average data of a larger number of tests, instead of the individual data points. The data sets were divided into categories which reflected one soil type, one equipment type, and one equipment use. The potential for useful analysis was limited to between-categories of a given data set or in a very few instances between data sets having somewhat similar characteristics. All the processed data and their respective sources are listed in Appendix A.

Statistical testing began with the Shapiro and Wilk test for normality, as presented by Anderson and Mclean (20), on each individual category. The unit weight and water content of all laboratory categories were normally distributed. However, some categories of data which were from field compaction tests were found to be not normally distributed. This severely limits the inference base which additional analysis might produce, at least until a

suitable transformation might be made on such data. Part of the reason for this lack of normality is that the field compaction tests were performed at intermittent water content levels (i.e., low, near optimum and high), unlike the laboratory data which is produced at gradual increments of water content. Although the unit weight versus water content curves develop as expected, a low level of normality is indicated. Figure 3 illustrates the distribution of a typical data category of this type.

Between given categories of data set, a one-way analysis of variance (ANOVA) was performed. This was to determine if the differences in the behavior and characteristics of the compacted product were statistically significant; this had been previously assumed from research on the compaction process. The ANOVA is used to determine whether the data sets are significantly different from each other when compared on the basis of mean value and variance. The assumptions and limitations of this analysis are discussed by Scheffe (21), among others. A factorial computational program BMDIV (22) was used to determine the desired statistics from the analysis.

The density, molding water content, and strength (when available) from different compaction processes were treated in this analysis. The effects of energy input variations were analyzed under two conditions. For the laboratory test the blow/per layer or foot pressure was varied. For the field tests the number of passes was varied for similar equipment, except in one analysis where the equipment was modified and passes remained constant. The compaction results were tested by the ANOVA to indicate whether the increase in

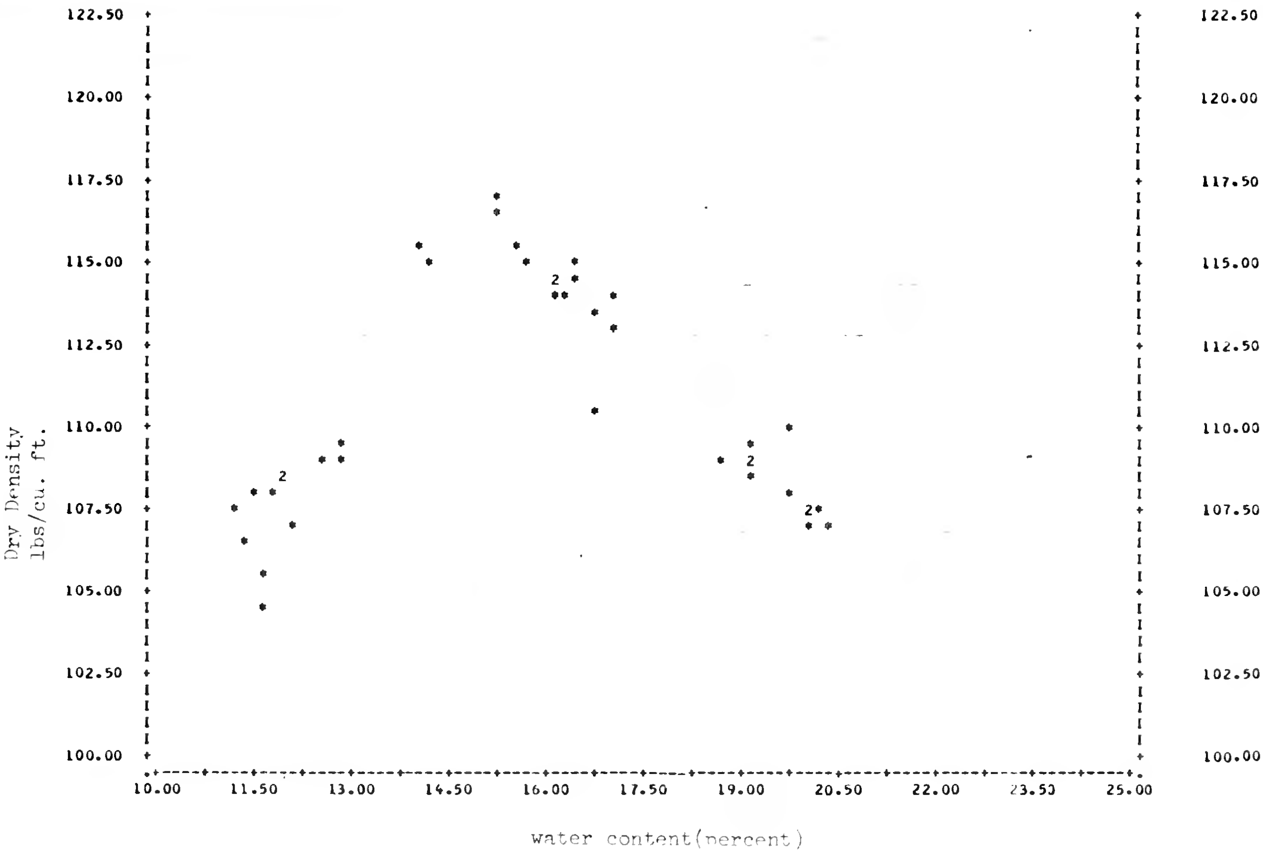


Figure 3. Typical Distribution of Non-Normal Field Data

energy input did have an affect on the compaction product. The results of the ANOVA are presented in Table 1.

As indicated on the table by the two comparisons of strength, the analysis shows that the change in strength (CBR) is non-significant across the levels of energy tested, contrary to what would normally be assumed. The indication of significance in the density in all ANOVA, excepting the sheepsfoot variation of foot pressure, reflects the expected trends from such compaction. The higher energy input into the soil mass produced a higher density across water content levels shown to be non-significant. The non-significant density difference for the variation of sheepsfoot foot pressure is also an expected trend, as reported by Johnson and Sallberg (23).

Since the analysis indicates a non-significant gain in strength (CBR) with a significant change in density and a non-significant difference in water content, either of two very preliminary conclusions could be proposed. First, the dependence of strength on density is minimal (in the range of densities tested) and responds to the changes in water content. Secondly, the variables considered may be of such magnitude that this apparent non-effect is masked and the total number of data gathered may be insufficient to provide a meaningful analysis on the variation of the as-compacted strength. Further analysis of similar testing should provide more support to one of the two arguments.

Several regressions of data categories were performed to indicate general trends of equations which might be expected for similar soil types. It had been hoped that strength data would be present for both field and lab compaction. With such data, an

TABLE 1

Summary Analysis of Variance (One-Way) Between Slightly Different Compaction Procedures

I.D.*	Soil Type	Compaction Constants	Compaction Variable	Variable Tested	Significant** at 5% Level
XXX	A-6(10)	Lab., 5 layers, 10 lb. hammers, 18" drop	Blow/layer 55,26,12	CBR	NO
				Dry Density	YES
				Water Content	NO
XXX	A-6(10)	Field, Sheepsfoot 7 in^2 feet	No. of Passes 6,12,24	Dry Density	YES
				Water Content	NO
XXX	A-6(10)	Field, Sheepsfoot 14 in^2 feet	No. of Passes 6,12,24	Dry Density	YES
				Water Content	NO
PP	A-6(10)	Lab., 5 layers, 10 lb. hammer, 18" drop	Blow/layer 55,26,12	CBR	NO
				Dry Density	YES
				Water Content	NO
PP	A-6(10)	Field, Sheepsfoot 14 in^2 feet (12 Passes)	Foot pressure 125,375	Dry Density	NO
				Water Content	NO
PP	A-6(10)	Field, Rubber Tired Roller 50 psi	No. of Passes 4,8,16	Dry Density	NO
				Water Content	NO
PP	A-6(10)	Field, Rubber Tired Roller 150 psi	No. of Passes 4,8,16	Dry Density	YES
				Water Content	NO
YYY	A-6(10)	Lab. Kneading Comp.	Foot Pressure 300,200, 100 psi.	Dry Density	YES
				Water Content	NO

* SEE APPENDIX A FOR REFERENCE SOURCES

**Based on comparison of table value of "F" value at $\alpha = .05$; if computed value is greater than table value then significant, if less than then non-significant.

estimate could be made of the capability of predicting the field strength relationship from laboratory data. However, this combination has not been observed in any of the data sets processed. Subsequently, regressions were made for dry density as a function of water content (w) for a given soil, roller, and roller use. After preliminary computations with an "all-possible" regression technique, the final regressions were based on dry density as a function of w, w^2, and w^3. The regression technique used is one outlined by Draper and Smith (24) and the regression routine of the SPSS computational system (25).

The equations generated and the relative fit index, R^2, are shown in Table 2. Some similarities of equations can be noted from the table; equations 4 and 6 are remarkably similar. Also similar trends are apparent between equations 1 and 3. The relative fit index, R^2, indicates how well the regression fits the actual data points. Equations 4 and 5 exhibit remarkable fits; however, equation 6, while being very similar in form to equation 4, shows a relatively poor fit. This reflects one of the most frequent problems in comparing data from different sources. The criteria used for reporting good data may be widely different. In attempting to assess variability this is very crucial and limits analysis across data sets and in some areas within the data sets.

In summary, the published data have not produced enough detailed information to completely explain the source of the differences (or similarities) noted nor the source of the variabilities noted. Additional sources of data are being pursued.

TABLE 2

Regression of Dry Density as Function of Water Content

ID*	Soil Type	Field or Lab	Equipment Type and Use	No. of Data Points	Equation**	R^2
PP	A-6(10)	Field	Sheepsfoot, 14 in^2 Sect. 125 psi, 12 passes	16	(1) $\gamma_d = 454. - 75.7\ w + 5.28\ w^2 - 0.119\ w^3$	0.76
PP	A-6(10)	Field	Sheepsfoot, 14 in^2 feet 375 psi, 12 passes	15	(2) $\gamma_d = -918. + 167.\ w - 9.04\ w^2 + 0.16\ w^3$	0.95
PP	A-6(10)	Field	Rubber Tired, Roller, 50 psi 4 passes	19	(3) $\gamma_d = 246. - 30.5\ w + 2.02\ w^2 - 0.042\ w^3$	0.85
BBB	A-6(10)	Lab	5 layers, 12 blows/layer 10 lb. hammer, 18 in. drop	11	(4) $\gamma_d = 86. - 0.9\ w + 0.27\ w^2 - 0.009\ w^3$	0.97
BBB	A-6(10)	Lab	5 layers, 26 blows/layer 10 lb. hammer, 18 in. drop	11	(5) $\gamma_d = 64. + 4.6\ w - 0.03\ w^2 - 0.005\ w^3$	0.98
CCC C	A-6(11)	Lab	STD. Proctor	36	(6) $\gamma_d = 101. - 0.93\ w + 0.21\ w^2 - 0.007\ w^3$	0.69

* See Appendix A for source reference.

**γ_d in lbs/ft^3 and w in percent.

ISHC Data

Data were collected at the Materials and Testing Center of the ISHC. By analyzing these actual construction data on the indigenous soils, the variabilities and differences from different compaction processes could possibly be identified and related to their respective sources for the actual compaction projects in the State of Indiana.

Daily construction records of recently completed or in-progress projects were examined and appropriate data recorded. The following information was taken from these records:

project number

compaction equipment

number of passes of equipment

measured dry density

measured water content

Standard Proctor maximum dry density and optimum water content (as listed for typical soil after visual identification).

When certain pieces of information were unavailable on the daily records, appropriate field sources were contacted to complete as much data as possible. An example of a typical record sheet is shown in Figure 4.

The laboratory dry density and CBR versus water content curves and soil classification information was also recorded. Because no Atterberg limits tests are performed by ISHC personnel and a listing of typical Proctor maximums and optimum water contents is used with visual classification, a complete set of the above data has not been located for all the soil types encountered in the recorded data.

File

CONTRACT NO. R-7934 PROJECT NO. RS-5836 (3) ROAD NO. SR-61 DATE 10-22-70 WEATHER CLEAR-COOL

	Field Test No.	M-65
Location of Tests	Station	496+00
	Reference to Centerline	18' LT. ON LT. SHOULDER
	Elevation or Lift No.	#4 SUBBASE
	Loose Depth of Lift	7"
	Compacted Depth of Lift	6"
	Method of Compaction	VIBRATOR-ROLLER
	No. of Passes with Roller	5
Soil	A. Wet Wt. Soil & Container (Lbs.)	6.31
	B. Wt. of Container (Lbs.)	1.63
	C. Net Wt. of Soil (Lbs.) (A–B)	4.68
Sand Cone	D. Initial Wt. Sand & Container (Lbs.)	17.46
	E. Final Wt. Sand & Container (Lbs.)	10.09
	F. Net Wt. of Sand (Lbs.) (D–E)	7.37
	G. Wt. of Sand in Cone (Lbs.)	3.72
	H. Wt. of Sand in Hole (Lbs.) (F–G)	3.65
	I. Density of Sand (Lbs./Cu. Ft.)	98.3
Rubber Balloon	J. Final Reading (Cu. Ft.)	X
	K. Initial Reading (Cu. Ft.)	X
	L. Vol. of Hole (Cu. Ft.) (J–K)	X
	M. *Wet Density of Soil (Lbs./Cu. Ft)	126.0
	N. Per Cent of Moisture in Soil	6.8
	O. **Dry Density of Soil (Lbs./Cu. Ft.)	118.0
	P. Maximum Dry ~~Wet~~ weight from curve (Lbs./Cu. Ft.)	116.2
	Q. Per Cent of Maximum Dry ~~Wet~~ Density	101.5
	R. Per Cent of Maximum Dry ~~Wet~~ Density Required	100.0
	Test Remarks	O.K.

The undersigned is not assigned to, or associated with this project. I have observed these tests and verified that proper test procedures were used and hereby certify these test results. RUN

Signed Virgil R. McKee
Record Sampler

"This is maximum density data for Lab # V70-50272 obtained for Record Density Test No. M65, dated 10-22-70

128.1	Max. Wet Den.
114.1	Max. Dry Dens.
12.3	Opt. Moisture

RECEIVED
FEDERAL HIGHWAY ADMINISTRATION
NOV 16 1970
DIVISION OFFICE
INDIANAPOLIS, INDIANA

$^{*}\ \frac{\text{Net Soil Wt. (C)}}{\text{Wt. Sand in Hole (H)}} \times \text{Sand Density (I)};\ \text{or}\ \frac{\text{Net Soil Wt. (C)}}{\text{Vol. of Hole (L)}}$ $^{**}\ \frac{\text{Wet Density}}{100 + \%\ \text{Moisture}} \times 100$

Figure 4. Typical Data Sheet Signed Virgil R. McKee

Standard classification tests were performed on some of the soil types by commercial labs. Unfortunately, there was no exact match up between a given field soil and the commercial data results.

The data obtained from the daily records were separated into categories. Each category represented one soil type, one type of equipment and one level of compaction energy. The soils were classified according to the AASHTO classification system. This resulted in 48 categories being established. The soil type and levels of energy were somewhat arbitrarily established as outlined below. The categorized data are presented in Appendix B.

The selection of a soil type for a category was, at best tenuous. In order to make any classification, several field compacted soils which had slightly different maximum dry density and water content values had to be lumped together with a laboratory compacted soil having similar maximum and optimum values. Several attempts were made to categorize the data using only field information. This produced categories with fewer rational differences than the previous method. Since these were categories still contained the same undesired statistical nature as the laboratory based categories, the laboratory comparison was used to define the categories. The main emphasis in this correlation was placed on the water content values, since the dry density values could likely have a wider spread.

If the optimum water content from the field compacted soil was approximately equally spaced between two different optimum water contents from laboratory compacted borrow soils, the following

procedure was used. Assuming that the true optimum of the field compacted soil is actually equal to the optimum of one of the two corresponding laboratory compaction data, then the resulting maximum density from the erroneous field optimum should be less than the maximum density of the true optimum (that is with the water content of the field compacted soil not equal to the optimum, the resulting dry density will be less than the maximum). Consequently, the laboratory optimum water content which had a higher maximum density than the field maximum was chosen as the correct soil type. In the above, maximum of the field compacted soil, refers to the listing of laboratory values assigned to that soil in the field by the engineer. Having chosen an optimum and maximum density, a classification was made of the soil type. In some cases no reasonable match was obtainable and the soil was left unclassified.

As stated before, the estimate of energy levels (number of pass-es) is also subject to interpretation. Sometimes this information is estimated by the grade foreman or is listed on the records as variable.

Instead of using all of the ISHC data in the initial analysis, only specific sets of data were chosen to bound all the data. An upper and lower bound was established for 1) soil type, 2) equipment and 3) energy. These bounds were not the most extreme values observed in the data, but were confined to values of soil type, equipment, and energy which were in sufficient number of combinations to permit an analysis. In doing this it was hoped that all combinations of each high and low level of the values could be listed; however, the best possible selection of data yielded only 5 of the 8 combinations. Table 3 lists the levels of the variables which were used and the

TABLE 3

Extreme Combinations of Compaction Variables from ISHC Data Used for Analysis

Levels		
Soil (S)	High	A-6(11)
	Low	A-7-6(15)
Energy (e)	High	6 passes
	Low	3 passes
Equipment (E)	High	FWD*
	Low	Sheepsfoot*

Combination available

S_L E_H e_L

S_L E_L e_L

S_L E_L e_H

S_H E_H e_H

S_H E_L e_L

*Equipment information as reported by Field as follows:

FWD - a self-propelled sheepsfoot weighing approximately 20 tons

Sheepsfoot - a tractor-pulled roller weighing 5 - 6 tons.

combinations available for analysis.

Unit weight and water content of all 5 sets were tested for normality by the Shapiro and Wilk Test (20) or where computation limits were exceeded, by the Kolmogorov Smirnov Test (26); all were found to be in the range of acceptable normality. Since all combinations were not present it became impossible to perform ANOVA on the separate levels of each factor. Therefore a one-way ANOVA was performed on all 5 sets to test for significant difference. The ANOVA indicated that dry density did not vary significantly from group to group even at the lower confidence level of $\alpha = 0.10$. Water content was also non-significant.

It is apparent from reviewing the data that high and low values of density appear at the same moisture content. Figure 5 illustrates this for all sets having A-6(6-12) soil type. The mean and variance of each set were computed and plotted in Figures 6 & 7. No readily apparent relationship appears to exist between the magnitude of the mean values and the variance. The within-variances of the categories were found to be non-homogeneous by the Burr-Foster Test (20) and prevented further analysis of the data as a complete set.

The data from the ISHC show very large variability. This could be attributed to the categorization by the indefinite measures of soil typing and number of passes, or to the data themselves. The form of the data is such that differences cannot be detected statistically between logical categories. The large variations within a category prevent the detection of what could be smaller variations between categories. Therefore, the variabilities in the compacted

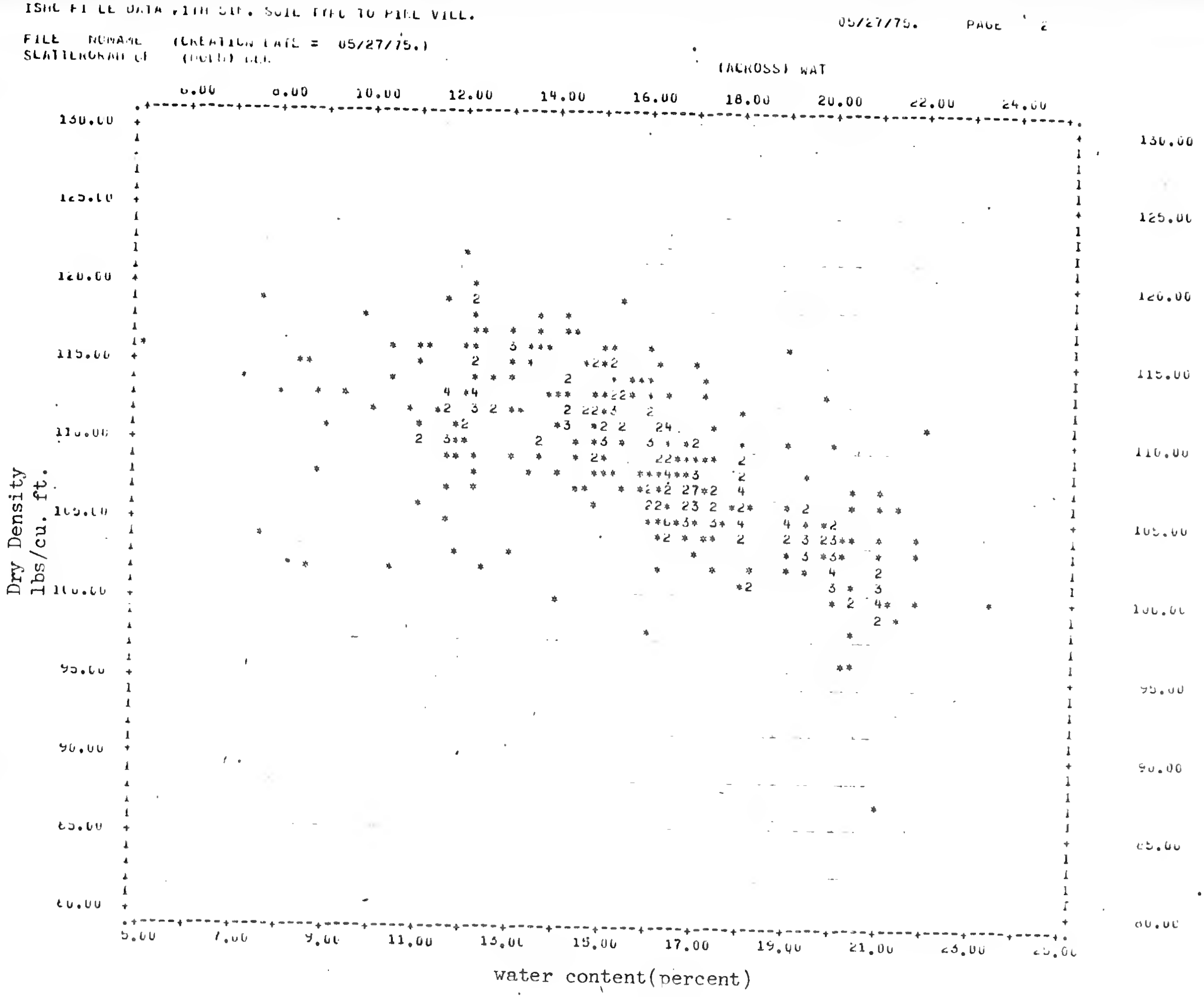


Figure 5. Distribution of Data for ISHC Compaction Records Having Soil Type A-6(6-12)

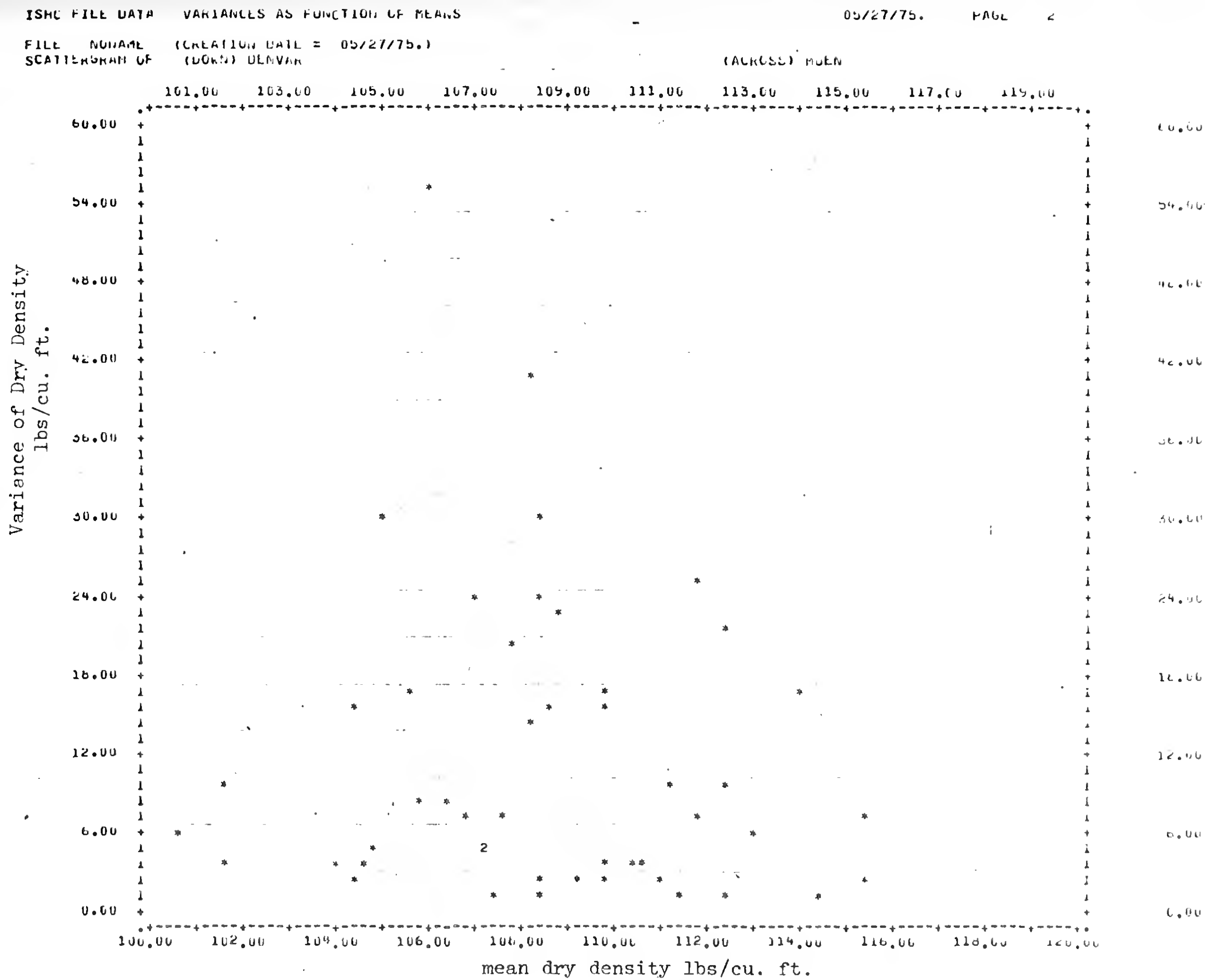


Figure 6. Variance of Density versus Mean Density for all Categories ISHC Data

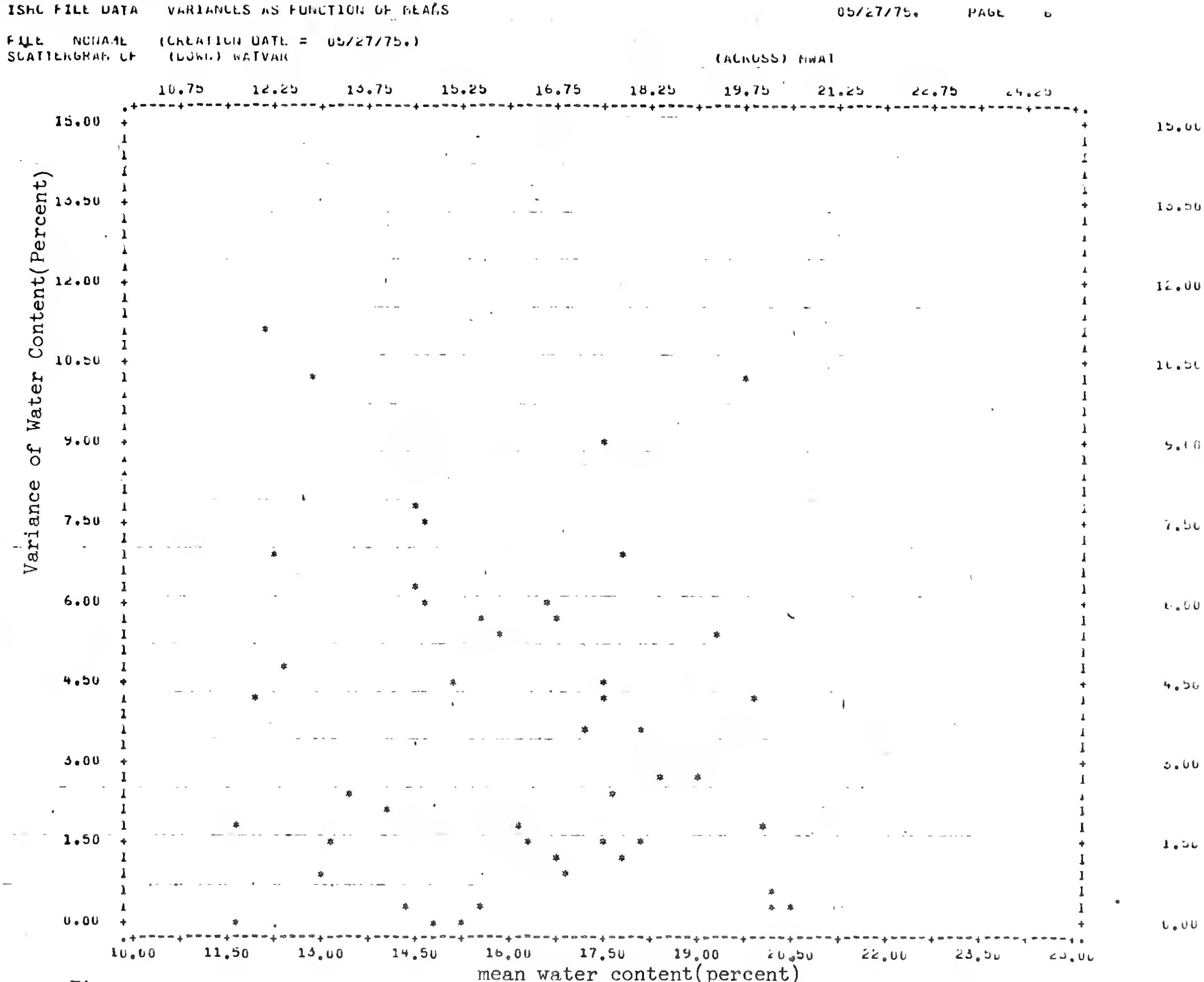


Figure 7. Variance of Water Content versus Mean of Water Content for all Categories ISHC Data

density as caused by some specific variable in the compaction process have not been established using this source of data. A continued effort will be made for data collection to see if this matter can be clarified in the future.

Original Field Data

An effort was made to establish a relationship for the field and laboratory strength and variability. A field sampling and laboratory compaction program was, thus, undertaken.

Using the data from ISHC sites previously discussed, the range of expected standard deviations was obtained, and an estimate was made for the number of samples required for a satisfactory analysis. It was decided to take approximately 10 sets of samples with each set consisting of 4 to 6 tube samples.

After being forced to discard a project site because the borrow contained too much coarse material for our purposes, Project STF-95(12) located near Carbondale, Indiana was utilized. The borrow for this project was very variable having been obtained from several small pits and side ditches. The fill was placed so rapidly along the 5 mile long project, that a systematic testing procedure was impossible. As a result, the samples were taken at the location of the ISHC density tests, immediately after the ISHC personnel completed their testing.

The primary piece of compaction equipment was a self-propelled "Hyster" Model C450B. This is a tamping foot roller weighing approximately 27 tons and having a nominal foot pressure of approximately 225 psi. Operation appeared to produce 4 to 6 passes in most regions.

This information was obtained from the grade foreman at each location.

From the sampling, the variation at one location of the strength, dry density, and water content was to be established. To achieve this, at each location 4 drive tube samples, 4 sets of dynamic cone penetrometer readings, and approximately 100 pounds of bag sample were taken. Figure 8 illustrates the geometric layout of the sampling.

The dynamic cone penetrometer measurements were taken in an area undisturbed by the tube sampling. The apparatus and procedure followed are described by Van Vurren (27), the values recorded for the approximate depth of the samples were averaged and then converted to CBR using the generalized curve shown in Figure 9.

On the soil from the bag samples Atterberg Limits tests and a minus No. 200 sieve wash were performed. The soil type for each location and the number of samples tested are shown on Table 4. As noted from the table there were very few locations where all four strength samples were tested. The heterogeneous nature of the fill (including stones and dry layers) prevented the recovering of sufficiently long samples.

The last four locations tested were not made at sites tested by ISHC personel. This was necessary in order to obtain a sufficient quanity of samples before the close of the construction season. In these tests a sand cone density check was performed in the same geometric location as before.

Because of the non-uniformity of soil type the analysis was limited to these locations having a soil classification of A-6(6) thru

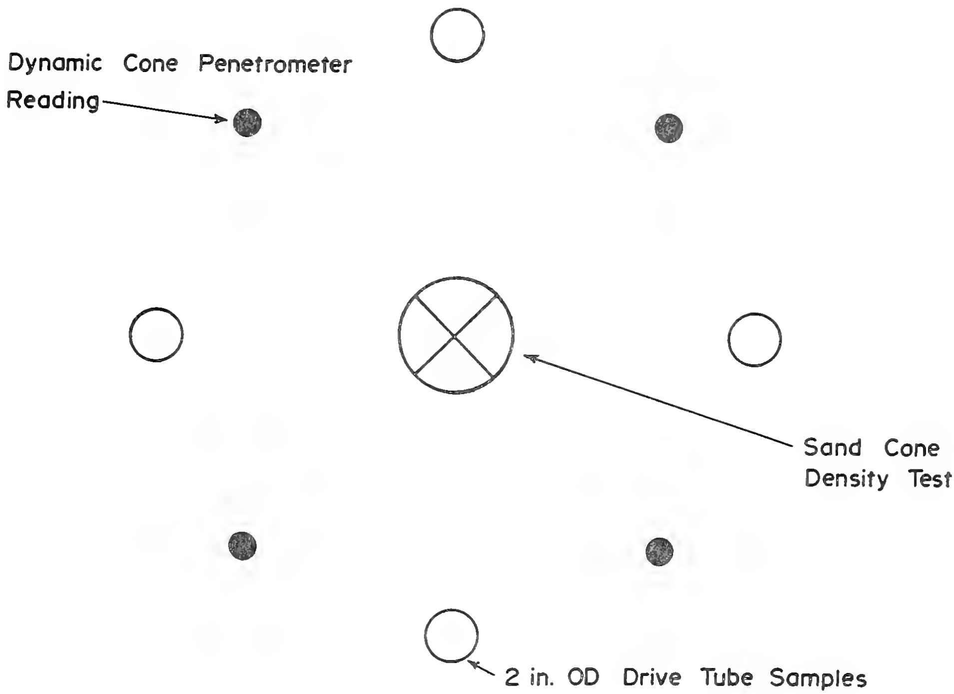


FIGURE NO. 8 TESTING PLAN AT EACH LOCATION.

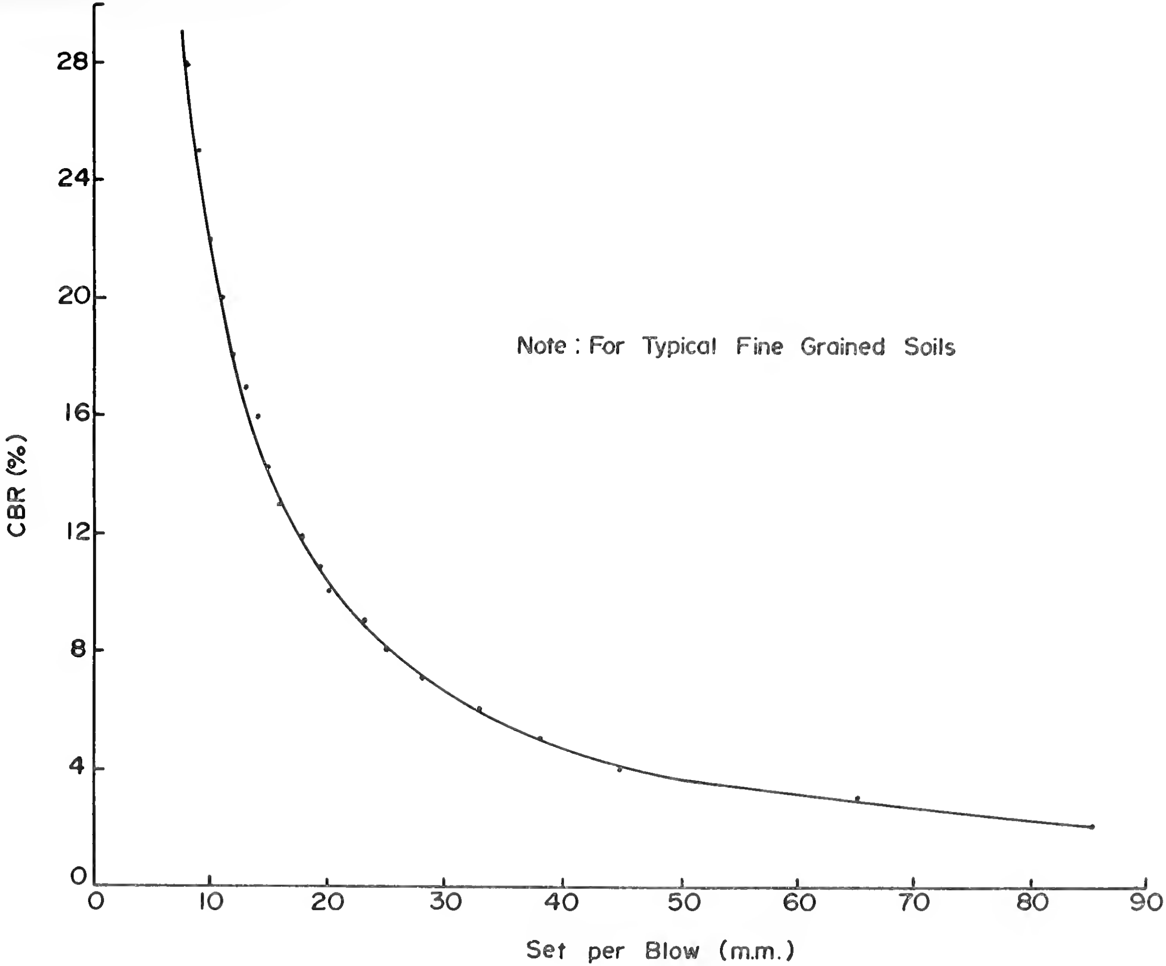


FIGURE NO. 9 CONVERSION OF DYNAMIC CONE PENETROMETER SET TO CBR (%).
(AFTER VANVURREN (27))

Table 4

Soil Type and Samples Tested For Locations On Project STF-95(12)

Location No.	Soil Type	No. of Unconfined Samples Tested
1	A-7-6(13)	0
2	A-7-6	0
3	A-7-6(13)	4
4	A-6(10)	3
5	A-6(10)	3
6	A-6(6)	2
7	A-6(6)	3
8	A-7-6(12)	0
9	A-6(9)	4
10	A-6(7)	3
11	A-6(10)	2
12	A-6(10)	3
13	A-6(11)	4

A6(11). The test data for these samples and locations are listed in Table 5; the density measurements made from the physical measurements of the tube samples are also shown. There was not good agreement between these and the sand-cone measurements. The geometric densities were usually higher than the sand-cone densities by about 6 percent. This was attributed to the general tendency of the sand cone test to under-estimate density and to some compression of the tube samples during extrusion. The water contents are those obtained after the strength testing. There was usually very good agreement between the field water content and the as-tested water content.

Figure 10 shows the distribution of dry density and strength versus water content for the data obtained.

Since the actual numbers of passes and other equipment travel were not known, the analysis of the data was performed on a location basis, i.e., each location was treated as a data set and tested against the other locations. An ANOVA was used to test dry density, water content, and unconfined strength. The testing indicated that all three variables showed significant differences across location. This significance in dry density and water prevented an analysis of covariance (ANCOVA) from being used; covariance would have tested if the differences in strength could be attributed to variations in density and/or water content. Two locations were suspected of being subjected to a higher energy input. They were deleted, but the rerun ANOVA produced similar results.

The ANOVA indicated that the difference in strength across locations could be attributed primarily to differences in water

Table 5

Data From Field Compacted Samples

Location	Dry Density (lbs/cu.ft.)	Water Content (percent)	Max. Compression Stress (psi)	Failure Strain (percent)	Equivalent CBR (percent)
4	117.3	14.1	32.9	7.0	5.1
	117.7	13.3	32.5	6.8	4.4
	116.7	14.4	46.4	3.8	5.7
5	104.5	13.8	40.6	2.0	5.8
	118.2	13.9	34.7	5.8	5.6
	104.6	16.7	27.9	3.2	5.7
6	123.8	10.1	46.0	3.1	9.0
	124.5	10.8	48.1	7.3	7.5
9	123.4	12.0	32.9	10.5	2.8
	126.2	11.7	31.7	12.4	3.4
	123.7	11.9	39.1	10.0	4.4
	117.1	14.7	19.2	9.5	3.8
10	117.8	15.0	20.0	11.2	3.1
	113.9	15.3	18.9	9.0	4.2
	111.1	17.6	22.2	13.1	4.3
11	113.4	16.6	30.2	5.8	6.2
	113.2	16.4	26.4	8.6	5.9
12	110.3	18.1	16.2	8.9	2.5
	106.2	20.0	11.0	8.6	2.0
13	114.4	15.6	23.4	13.0	3.8
	114.0	15.8	20.0	8.8	5.0
	114.7	15.4	23.1	9.1	5.6
	115.8	15.1	13.7	7.8	3.9

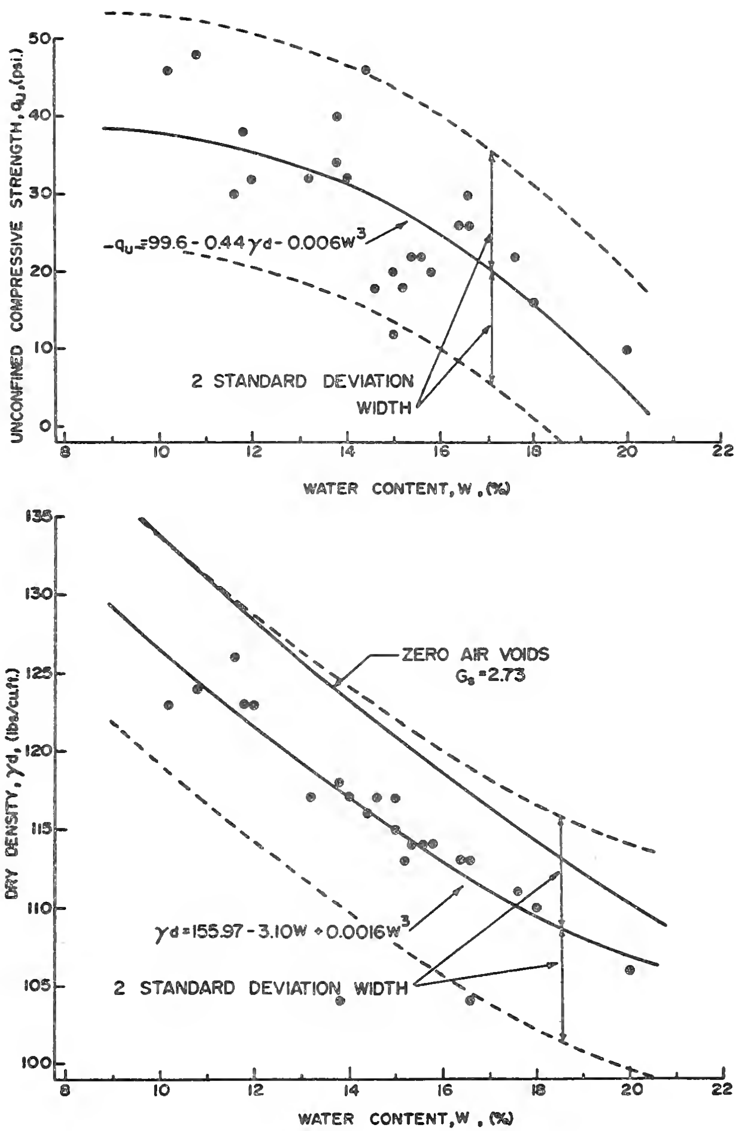


FIGURE NO. 10 RELATIONSHIP BETWEEN MOISTURE, DRY DENSITY AND UNCONFINED COMPRESSIVE STRENGTH FOR FIELD COMPACTION.

content, but the significant difference in water content across locations prevented a firm statistical inference to that conclusion.

The CBR, as obtained from the correlation with the dynamic cone penetrometer readings, was also investigated. General trends of CBR versus water content were indicated, but the correlation with any of the variables was poorer than that with the unconfined strength data. No additional analysis was attempted on the CBR measurements.

To establish the strength-water content-dry density field relationships, regression analyses were made for dry density (γ_d) as a function of molding water content (w) as well as for unconfined compression strength (q_u) as a function of γ_d and w. Various combinations and interactions were tested by an "all-possible" regression technique (with the cubic term being the highest order tested); the selected best functional relationships were as follows:

$$\gamma_d{}^* = 155.97 - 3.10\,w + 0.0016\,w^3$$

$$R^2 = 0.69 \qquad S_{Residuals} = 3.65 \text{ lbs/cu ft.}$$

$$q_u{}^* = 99.6 - 0.44\,\gamma_d - 0.006\,w^3$$

$$R^2 = 0.55 \qquad S_{Residuals} = 7.43 \text{ psi}$$

*where γ_d is in lbs/cu. ft., w in percent, and q_u in psi.

The two values listed under each regression can be used in evaluating how effective the regression is in representing the actual data. The R^2 is the same index as described previously. The $S_{Residuals}$ is a more quanitative statistic representing the standard deviation of the differences between the observed data and the regression. Obviously, a value for $S_{Residuals}$ of zero would indicate no differences, i.e., a perfect fit.

These regressions are also shown in Figure 10. The band width of $\pm$ 2 standard deviations show these to be somewhat loose fitting regressions. Exclusion of the two locations mentioned in the discussion of the ANOVA did not improve the fit of the regression and therefore all locations were retained.

Original Laboratory Data

The bag samples taken at each field location which were believed to represent the "same" soil were throughly mixed into one sample weighing approximately 800 pounds. Atterberg limits were performed and indicated a plasticity index of 16 and liquid limit of 29. The grain size distribution is shown in Figure 11. From the above soil indices, the sample was classified as a A-6(7). With this "average" soil, the laboratory density-water content-strength relationships were determined for different compaction procedures to roughly simulate the field compaction product. These relationships were compared to the field relationships. Also the variability of the different relationships was compared.

Preliminary laboratory work developed procedures for replication and control of external influences. As noted by Highter et al (17) the temperature during compaction and testing can greatly influence test results; thus the influence of temperature was kept at a minimum by compacting in a laboratory under moderately fluctuating temperatures and then storing and testing the samples in a controlled temperature room in which temperature variations were kept within approximately $\pm$ $2^{\circ}C$.

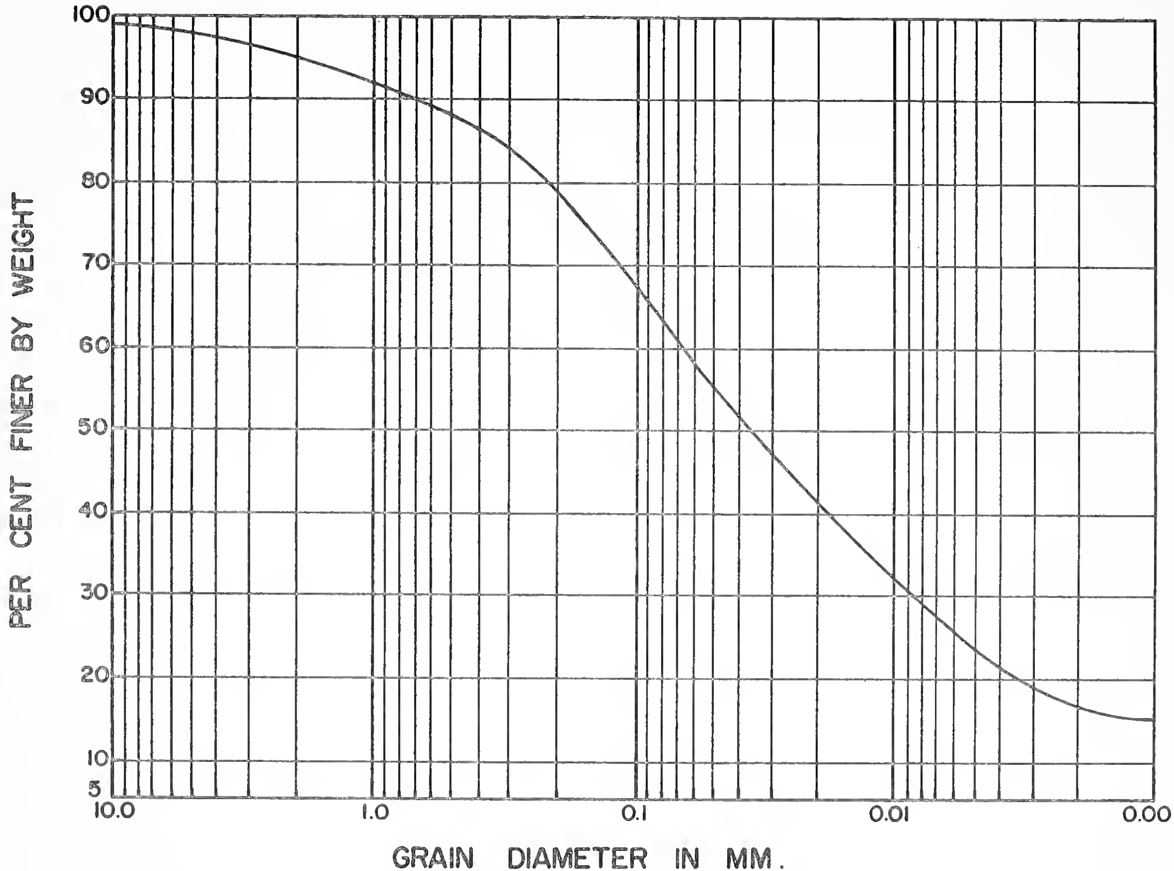


FIGURE NO. 11 GRAIN SIZE DISTRIBUTION CURVE.

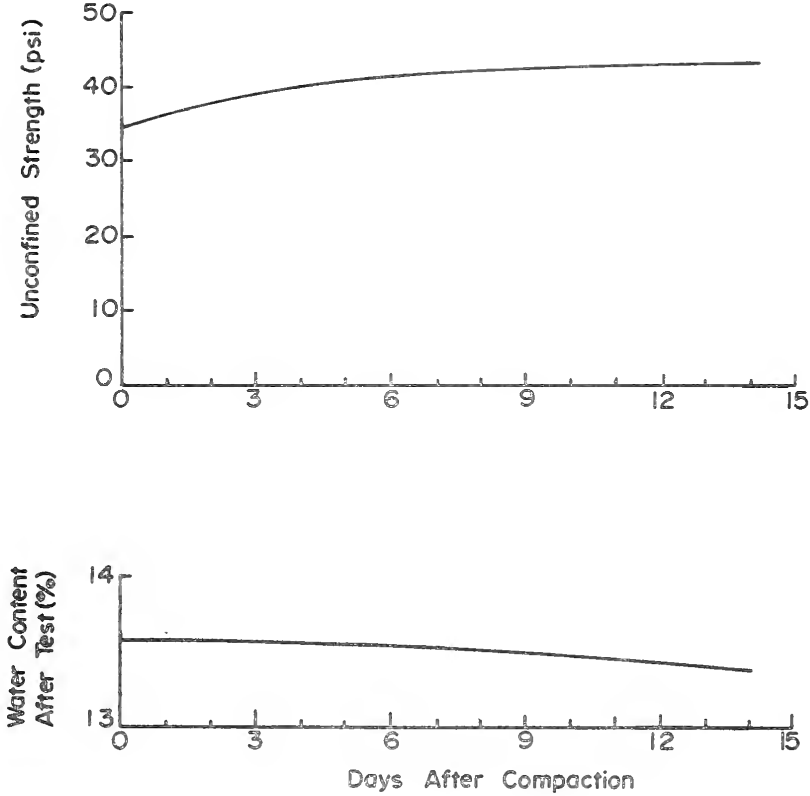
Time was also considered to be an important factor. After a sample batch was mixed it was placed in a humidity barrel overnight to encourage equal distribution of the moisture throughout the sample. The cure time before testing was investigated. By testing a set of the preliminary Harvard Miniature samples in a timed sequence, the change in strength due to moisture redistribution and environmental effects with time were observed as illustrated in Figure 12. The increase in strength is marked through about the fifth day after compaction. At this point further increases appeared primarily due to slight changes in water content. Because of these results, the strength testing was performed 5 days after compaction.

A deformation rate of 0.06 inch/per minute was selected as a constant for all samples tested. This resulted in an effective strain rate of approximately 2 percent per minute.

To aid in computation and data retention, an on-line analog computing device was devised such that corrected stress and strain were plotted as a stress-strain curve directly on a X-Y plotter during the conduct of a test. This recording procedure thus allowed for direct extraction of stress-strain relationships in all portions of the loading.

An outline of the complete testing procedure is contained in Appendix C.

The specification for the field compaction sampled was based on Standard Proctor compaction. Therefore it was decided to use the Standard Proctor in the laboratory. In order to reduce the volume of soil needed, Harvard Miniature compaction consisting of 10 layers,



Note : Values Shown are for Harvard Miniature (5 Layer, 40 Blows/Layer, 25 lb. Spring) at a Water Content of 13.6 %.

FIGURE NO. 12 TIME AND ENVIRONMENTAL EFFECTS ON UNCONFINED STRENGTH AND WATER CONTENT.

40 blows per layer with a 25 lb tamping spring, was also included in the laboratory compaction. The relationships for these two modes of compaction were developed and are shown in Figures 13 and 14.

The test data for both the Standard Proctor and Harvard Miniature test samples are listed in Tables 6 and 7, respectively. It should be noted that each Standard Proctor data set (excluding densities) is an average of the three to four samples cut from the Proctor mold. The density as determined by geometric measurements on each sample listed was subject to a large error, due to this type of measurement of volume; thus the respective mold density is reported. Each Harvard Miniature data represent one compacted specimen, with the mold density being reported. The water contents reported are the as-tested values. The as-tested water content values were found not to vary more than 0.75 percent from the batch mix.

Regressions were made for both the Standard Proctor and Harvard Miniature data. Dry density (γ_d) was computed as a function of water content (w), unconfined strength (q_u) was computed as a function of γ_d and w. The "best fit" regressions were computed are as follows:

Proctor

$$\gamma_d^* = 84.59 + 0.529\, w^2 - 0.0259\, w^3$$

$$R^2 = 0.77 \quad S_{Residuals} = 2.22 \text{ lbs/cu. ft.}$$

$$q_u^* = -64.64 + 0.92\, \gamma_d - 0.0045\, w^3$$

$$R^2 = 0.86 \quad S_{Residuals} = 3.75 \text{ psi}$$

HM

$$\gamma_d^* = -47.32 + 26.14\, w - 1.016\, w^2$$

$$R^2 = 0.89 \quad S_{Residuals} = 0.67 \text{ lbs/cu. ft.}$$

$$q_u^* = -91.16 + 1.56\, \gamma_d - 0.0187\, w^3$$

$$R^2 = 0.92 \quad S_{Residuals} = 4.00 \text{ psi}$$

* where γ_d is in lbs/cu. ft., q_u in psi, and w in percent. These regressions are also shown in Figures 13 and 14.

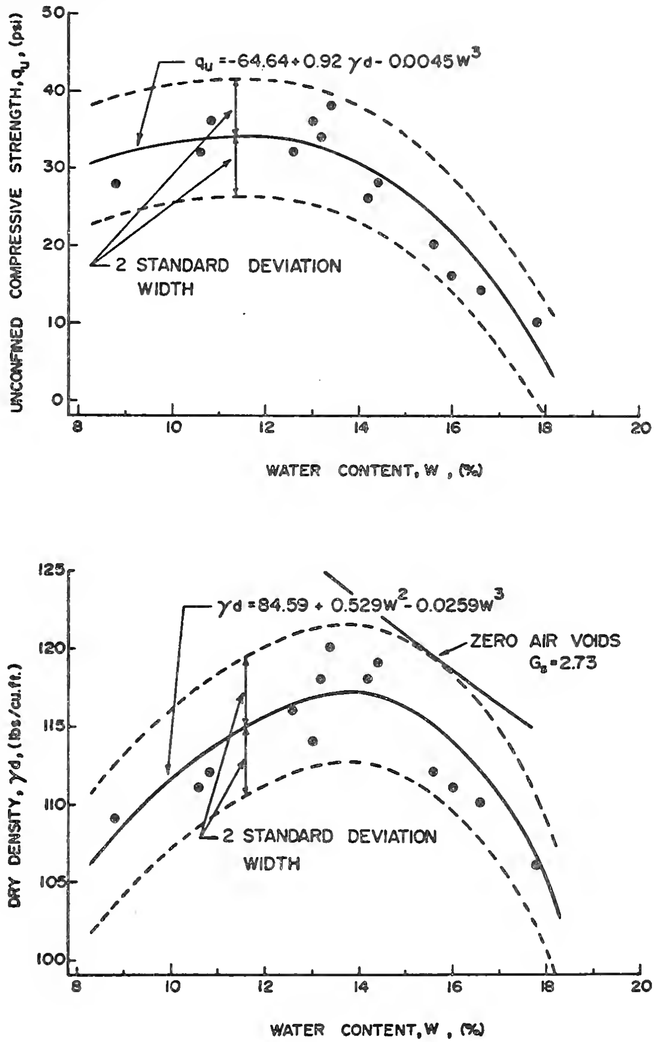


FIGURE NO. 13 RELATIONSHIP BETWEEN MOISTURE, DRY DENSITY AND UNCONFINED STRENGTH FOR A A-6(7) SOIL COMPACTED BY STANDARD PROCTER.

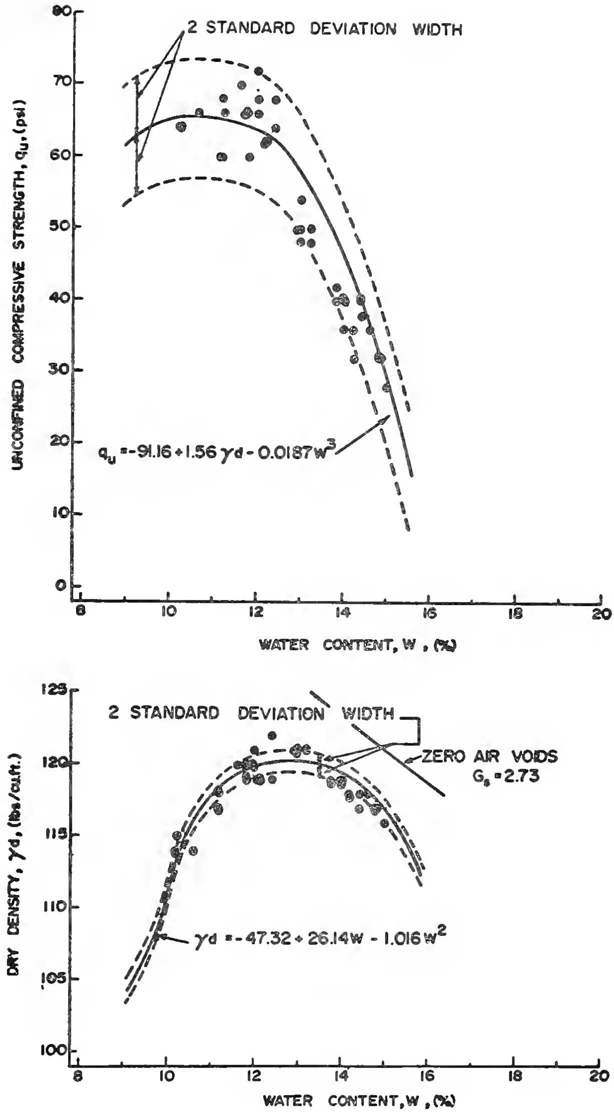


FIGURE NO. 14 RELATIONSHIP BETWEEN MOISTURE, DENSITY, AND UNCONFINED COMPRESSIVE STRENGTH FOR HARVARD MINIATURE COMPACTION OF A A-6(7) SOIL USING 10 LAYERS, 40 BLOWS PER LAYER AND A 25 POUND FORCE.

Table 6

Data From Standard Proctor Compacted Samples

Dry Density (lbs/cu. ft.)	Water Content (percent)	Max. Compressive Stress (psi)	Failure Strain (percent)
109.6	8.9	28.5	1.2
111.5	10.7	32.9	2.0
112.3	10.8	36.2	2.0
116.5	12.6	32.8	3.4
114.1	13.0	36.5	4.3
118.5	13.3	34.5	3.6
120.1	13.5	39.7	4.4
118.9	14.2	26.7	6.4
119.2	14.5	28.8	7.5
112.5	15.6	20.6	14.1
111.6	16.1	16.7	15.3
110.2	16.6	15.0	16.7
106.8	17.9	10.2	19.3

Table 7

Data From Harvard Miniature Compacted Samples

Dry Density (lbs/cu. ft.)	Water Content (percent)	Max. Compressive Stress (psi)	Failure Strain (percent)
115.1	10.3	64.2	1.3
114.5	10.3	64.0	1.5
114.3	10.3	64.2	1.4
114.6	10.7	67.5	1.5
117.7	11.2	60.5	2.2
118.1	11.2	67.0	2.2
117.8	11.3	60.5	2.2
118.4	11.3	68.0	2.2
120.3	11.7	71.0	2.6
119.9	11.8	67.0	3.2
120.1	11.8	67.0	2.8
120.2	11.9	61.0	2.6
119.9	11.9	67.3	3.3
120.6	12.0	67.0	3.9
120.1	12.0	68.6	4.0
121.9	12.1	72.0	4.8
119.3	12.2	63.0	3.2
119.1	12.3	63.0	3.0
119.8	12.3	62.8	3.7
119.5	12.4	65.5	3.3
122.1	12.4	69.3	6.9
121.2	13.0	49.2	11.2
121.5	13.1	55.3	14.5
121.3	13.1	51.8	13.0
121.4	13.1	51.3	11.8
121.3	13.2	51.8	13.6
121.3	13.2	49.8	12.6
119.9	13.8	41.8	14.4
119.7	13.8	42.8	16.0
119.4	14.0	40.0	16.8
119.2	14.0	41.8	16.2
119.4	14.0	41.0	17.0
119.2	14.1	37.3	17.0
118.5	14.3	32.5	16.0
118.7	14.3	36.0	16.6
118.2	14.5	38.5	15.5
118.5	14.5	40.3	17.0
117.4	14.5	40.3	17.6
118.1	14.6	37.0	17.2
117.3	14.8	33.0	20.0
117.2	14.8	32.8	20.0
117.1	14.9	32.0	20.0
116.6	15.0	29.8	20.0

The laboratory Proctor results indicate a maximum dry density of 117 pcf. With a specification requirement to obtain 95 percent of this maximum dry density, a passing compaction test could be obtained with a water content ranging from 10 percent to 17 percent. The laboratory strength varies from 32 psi to 17 psi within this water content range. Therefore, a passing compaction test can be obtained at a high water content, but the strength could be critically low under certain conditions. This analysis indicates strong support for moisture controls.

Laboratory-Field Comparison

Having the regression as developed in the previous sections for the field and laboratory compaction processes, comparisons were made. All the regressions are shown in Figure 15. The Harvard Miniature appeared to overestimate the field strength on the dry side. The Proctor reasonably approximated the field strength and was used in additional analysis.

It was desired to see how well the Proctor curve would predict the field strength. Using the field values of dry density and water content, predicted values of unconfined strength were computed using the laboratory Proctor regression. These results are illustrated in Figure 16. A Pearson correlation test was performed for the prediction versus observed data and yielded an index of 0.6558 (an index of 1 would indicate exact correspondence between the two variables while 0 would indicate no correspondence). A relation was developed between the observed value and value predicted by laboratory equations and is shown in Figure 16. The predicted values are shown to be generally slightly lower than the observed values over the range tested.

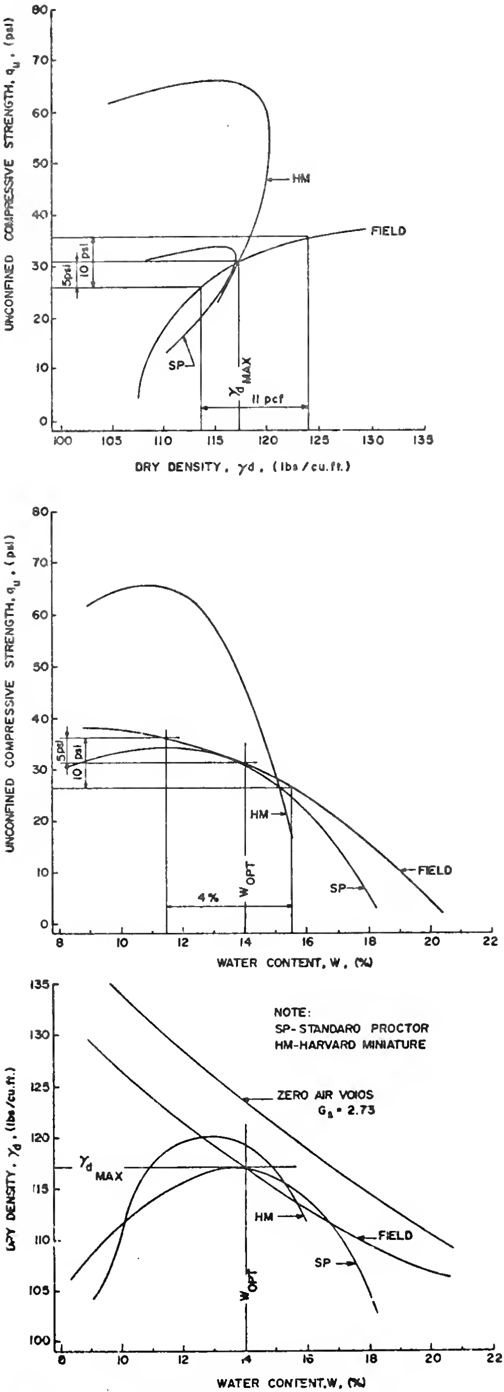


FIGURE NO. 15 COMPARISION OF REGRESSIONS FOR FIELD, HARVARD MINIATURE AND STANDARD PROCTOR COMPACTION.

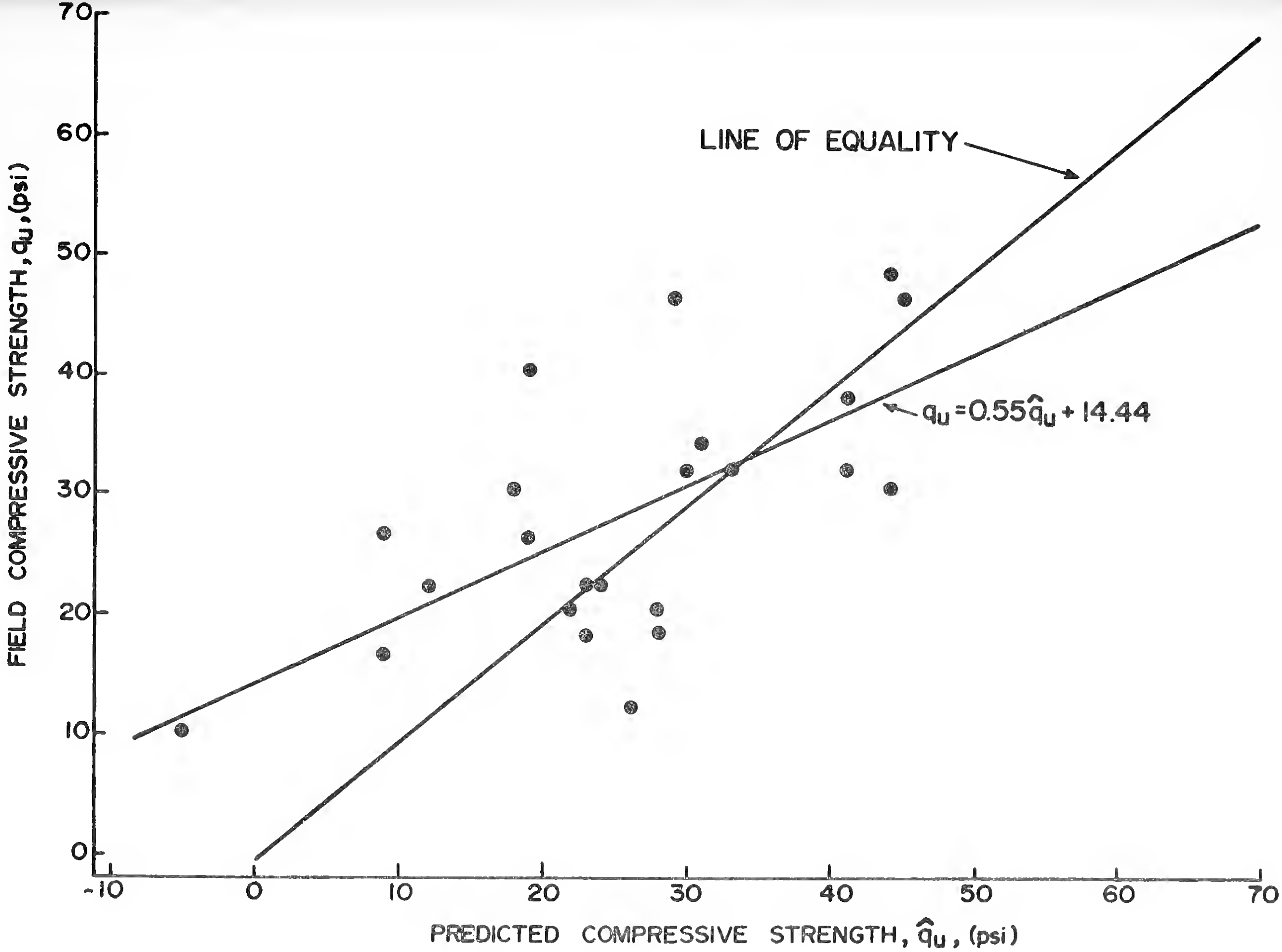


FIGURE NO. 16 OBSERVED FIELD UNCONFINED COMPRESSIVE STRENGTH VS. PREDICTED STRENGTH.

It appears that the field strength of this type of compaction for this soil can be reasonably predicted from the testing of laboratory compaction process. The variability of the laboratory process is sufficiently small such that a reasonable prediction function can be created to estimate the mean values of field strength. The extent of extrapolation beyond the magnitude of variables used here requires determination.

Discussions and Conclusions

Published Data

Data collected so far appear to have not displayed the desired sources of significant effects on the variability in the compaction processes. We have been unable to determine with any confidence where are the sources of the variability in the results of compaction. This is due for example to the scarcity of complete data for much reported work. We continue to investigate additional sources and will continue analysis in the hope of gaining much wider coverage than that of the variables examined in detail in the testing program.

ISHC DATA

The present form of the compaction records do not lend themselves to accurate analysis. The identification of soil type, equipment type, and equipment use are such as to make it difficult to compare the data in sufficient detail for analysis. But then, the large variability which was observed may not be due to categorization but actually may be present in the field product. Locations with more constant soil types and equipment may provide the necessary identification for analysis; collection of data will continue.

Original Field and Laboratory Data

The problems incurred in taking the field samples and in the length of time until each sample was tested have contributed to the variation found in the field data. Also additional test inconsistencies during this initial testing series may have added to the variation. Not being present during field compaction prevented a preparation of data by energy level of compaction, creating a possible source of error.

The only major problem in the laboratory compaction was the trimming of samples from the Proctor molds. This was remedied late in the test series by better development of technique.

Within the bounds of these data the regressions indicate that strength is not very dependent on the dry density of the compacted mass. Water content appears as the dominant variable in the field and Standard Proctor regressions. The field relationship developed can be used to illustrate this point. By using the strength (31 psi) at the optimum moisture content and maximum dry density as a reference, a $\pm$ 5 psi change in strength about this reference would result from an 11 pcf change in density or a 4% change in moisture. See Figure 15. It appears that water content control is critical if strength is to be considered as a design control.

The trend for the correlation between field and laboratory shown in Figure 16 is very encouraging. Although the source of variability has not been positively identified, the close approximation of the field strength by the initial laboratory curve is indeed encouraging. With the sources of variability more completely identified, the prediction of field strength should improve.

Ongoing studies will retest this approach and identify the relationships with a different soil type and possibly different field equipment. Also the influence of the compaction variables will be studied with respect to other observed characteristics such as modulus and failure strain.

Additional studies are also indicated for the influence of the compaction processes on the in-service behavior. Future studies will be done with environmental simulations of in-service conditions, possibly saturation and repeated cycling of wet and dry conditions. With this present study and the further work described above, it appears a frame work may be produced for predicting the field response from laboratory compaction processes. This will allow a more rational basis for establishing how to produce a finished product having behavior properties desired by the designer.

Recommendation

In order that the sources of the variabilities of the field compacted product can be isolated it is apparent that a test pad or section of test fill would be needed. With such a controlled procedure the field-laboratory relationships could be more correctly formulated. Then with this improved model of the compaction process, the influence of the more uncontrolled normal construction process could be evaluated. Accordingly, it is recommended that provision be made for such a test embankment; control and other measurements would be made by project personnel.

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Appendix A

Published Data

ID- W* LAB. HARVARD MINIATURE A-7-6(12)
WITH UNCONFINED TESTS

DRY DENSITY LBS / CU FT	WATER CONTENT PERCENT	MAX. STRESS** PSI
98.7	15.1	34.0
97.2	15.8	30.0
106.4	16.0	57.0
100.1	16.1	47.0
106.1	16.3	55.0
106.1	16.4	47.0
98.6	16.7	27.0
101.6	16.7	41.0
102.0	17.0	46.0
106.0	17.0	41.0
100.5	17.1	34.0
105.5	17.1	45.0
103.7	17.3	48.0
98.4	17.4	36.0
105.1	17.6	28.0
107.4	17.8	48.0
102.2	17.8	36.0
105.9	18.4	23.0
106.1	18.4	31.0
104.9	18.9	35.0
102.9	18.9	22.0
108.0	19.0	34.0
106.3	19.0	28.0
107.0	19.1	26.0
106.9	19.3	32.0
104.3	19.3	25.0
105.5	19.3	23.0
106.7	19.4	33.0
104.9	19.5	27.0
103.5	19.7	24.0
106.6	19.8	31.0
105.6	20.0	30.0
104.6	20.0	32.0
105.0	20.3	25.0
103.5	20.9	25.0
102.2	21.2	22.0
102.7	21.2	20.0
98.0	25.4	13.0
98.5	24.7	14.0
96.5	24.6	11.0
98.2	22.9	13.0
100.7	22.7	16.0
101.0	22.5	18.0
100.0	22.5	14.0
98.7	22.1	13.0
101.7	21.7	17.0
102.8	21.7	22.0

*See List of Sources

** -0 indicates no data given

ID- PP LAB. 5 LAYERS-10 LB HAMMER-55 BLOWS PER-18 IN. DROP A-6(10)
WITH CORRECTED CBR

DRY DENSITY LBS / CU FT	WATER CONTENT PERCENT	CORR. CBR PERCENT
111.7	11.8	102.0
113.5	13.6	88.0
114.0	15.6	42.0
111.5	17.5	10.0
107.0	19.2	5.0

ID- PP LAB. 5 LAYERS-10 LB HAMMER-26 BLOWS PER-18 IN. DROP A-6(10)
WITH CORRECTED CBR

DRY DENSITY LBS / CU FT	WATER CONTENT PERCENT	CORR. CBR PERCENT
104.1	12.0	53.0
105.7	13.8	53.0
108.3	16.0	45.0
108.6	17.9	18.0
105.6	19.7	5.0

ID- PP LAB. 5 LAYERS-10 LB HAMMER-12 BLOWS PER-18 IN. DROP A-6(10)
WITH CORRECTED CBR

DRY DENSITY LBS / CU FT	WATER CONTENT PERCENT	CORR. CBR PERCENT
96.3	12.1	32.0
98.0	14.3	31.0
100.0	16.2	28.0
101.2	17.8	22.0
102.3	19.6	13.0
101.3	21.8	3.0

ID- PP LAB. 5 LAYERS-10 HAMMER-55 BLOWS PER-18 IN. DROP A-6(10)
WITH UU TEST (CONFINING PRESSURE = 0.3 TSF)

DRY DENSITY LBS / CU FT	WATER CONTENT PERCENT	MAX. STRESS PSI
115.3	10.0	13.0
118.3	13.0	12.3
117.3	14.8	7.2
111.7	17.0	3.0
105.8	19.5	2.2
104.0	20.8	1.6

ID- PP LAB. 5 LAYERS-10 LB HAMMER-26 BLOWS PER-18 IN. DROP A-6(10)
WITH UU TEST (CONFINING PRESSURE = 0.3 TSF)

DRY DENSITY LBS / CU FT	WATER CONTENT PERCENT	MAX. STRESS PSI
108.4	10.0	7.5
113.2	12.7	8.1
116.1	15.0	5.5
110.7	16.8	4.2
103.4	21.3	1.4

ID- PP LAB. 5 LAYERS-10 LB HAMMER-12 BLOWS PER-18 IN. DROP A-6(10)
WITH UU TEST (CONFINING PRESSURE = 0.3 TSF)

DRY DENSITY LBS / CU FT	WATER CONTENT PERCENT	MAX. STRESS PSI
103.5	10.0	4.5
107.5	13.3	5.0
111.0	15.3	4.6
109.7	17.2	3.5
109.3	18.7	2.7
105.4	20.7	1.8

ID- PP LAB. 5 LAYERS-10 HAMMER-55 BLOWS PER-18 IN. DROP A-6(10)
WITH UU TEST (CONFINING PRESSURE = 1.0 TSF)

DRY DENSITY LBS / CU FT	WATER CONTENT PERCENT	MAX. STRESS PSI
115.3	10.0	14.7
118.3	13.0	12.7
117.3	14.8	9.6
111.7	17.0	4.5
105.8	19.5	2.3
104.0	20.8	2.0

ID- PP LAB. 5 LAYERS-10 LB HAMMER-26 BLOWS PER-18 IN. DROP A-6(10)
WITH UU TEST (CONFINING PRESSURE = 1.0 TSF)

DRY DENSITY LBS / CU FT	WATER CONTENT PERCENT	MAX. STRESS PSI
108.4	10.0	8.5
113.2	12.7	8.0
116.1	15.0	6.0
110.7	16.8	5.0
103.4	21.3	1.4

ID- PP LAB. 5 LAYERS-10 LB HAMMER-12 BLOWS PER-18 IN. DROP A-6(10)
WITH UU TEST (CONFINING PRESSURE = 1.0 TSF)

DRY DENSITY LBS / CU FT	WATER CONTENT PERCENT	MAX. STRESS PSI
103.5	10.0	6.9
107.5	13.3	8.0
111.0	15.3	5.0
109.7	17.2	3.5
109.3	18.7	2.6
105.4	20.7	2.1

ID- PP LAB. 5 LAYERS-10 HAMMER-55 BLOWS PER-18 IN. DROP WITH UU TEST (CONFINING PRESSURE = 3.0 TSF) A-6(10)

DRY DENSITY LBS / CU FT	WATER CONTENT PERCENT	MAX. STRESS PSI
115.3	10.0	18.5
118.3	13.0	15.5
117.3	14.8	11.4
111.7	17.0	5.5
105.8	19.5	3.5
104.0	20.8	2.4

ID- PP LAB. 5 LAYERS-10 LB HAMMER-26 BLOWS PER-18 IN. DROP WITH UU TEST (CONFINING PRESSURE = 3.0 TSF) A-6(10)

DRY DENSITY LBS / CU FT	WATER CONTENT PERCENT	MAX. STRESS PSI
108.4	10.0	12.0
113.2	12.7	12.5
116.1	15.0	8.6
110.7	16.8	7.0
107.6	18.7	4.3

ID- PP LAB. 5 LAYERS-10 LB HAMMER-12 BLOWS PER-18 IN. DROP WITH UU TEST (CONFINING PRESSURE = 3.0 TSF) A-6(10)

DRY DENSITY LBS / CU FT	WATER CONTENT PERCENT	MAX. STRESS PSI
103.5	10.0	9.1
107.5	13.3	8.7
111.0	15.3	7.2
109.7	17.2	5.6
109.3	18.7	4.5
105.4	20.7	2.2

ID- PP FIELD SHEEPSFOOT-14 SQ IN FEET-125 PSI-12 PASSES A-6(10)

DRY DENSITY LBS / CU FT	WATER CONTENT PERCENT	DRY DENSITY LBS / CU FT	WATER CONTENT PERCENT
96.8	12.3	100.0	12.5
103.2	12.1	99.3	13.2
101.4	13.7	102.6	14.1
108.3	15.7	109.3	15.8
108.8	16.3	106.0	16.2
105.7	16.6	107.8	16.6
109.3	17.0	104.7	17.1
109.0	17.8	108.0	18.5

ID- PP FIELD SHEEPSFOOT-14 SQ IN FEET-375 PSI-12 PASSES A-6(10)

DRY DENSITY LBS / CU FT	WATER CONTENT PERCENT	DRY DENSITY LBS / CU FT	WATER CONTENT PERCENT
100.5	14.3	102.8	14.5
102.6	14.6	104.9	14.8
105.7	14.9	107.8	16.1
108.8	16.2	108.7	16.5
109.0	16.8	108.7	16.9
109.0	17.3	110.2	17.3
107.7	17.7	107.3	18.2
106.3	18.7		

ID- PP FIELD RUBBER TIRED ROLLER-50 PSI-4 COVERAGES A-6(10)

DRY DENSITY LBS / CU FT	WATER CONTENT PERCENT	DRY DENSITY LBS / CU FT	WATER CONTENT PERCENT
99.5	13.6	98.5	14.1
99.8	14.8	99.1	15.2
102.2	16.2	103.3	16.1
104.3	16.1	103.2	16.3
101.8	17.2	106.0	17.7
106.8	17.8	105.3	18.2
105.7	18.2	106.0	19.1
106.3	21.1	105.9	21.3
105.4	21.3	105.1	21.5
103.2	22.3		

ID- PP FIELD RUBBER TIRED ROLLER-50 PSI-8 COVERAGES A-6(10)

DRY DENSITY LBS / CU FT	WATER CONTENT PERCENT	DRY DENSITY LBS / CU FT	WATER CONTENT PERCENT
101.2	14.3	101.2	14.8
101.7	14.8	104.7	16.3
105.2	16.5	106.3	16.7
105.8	17.0	107.3	17.7
106.2	18.2	106.5	18.2
106.9	18.2	107.3	18.3
106.2	18.3	104.4	21.7
103.9	22.1	100.7	23.2
101.1	23.6		

ID- PP FIELD RUBBER TIRED ROLLER-50 PSI-16 COVERAGES A-6(10)

DRY DENSITY LBS / CU FT	WATER CONTENT PERCENT	DRY DENSITY LBS / CU FT	WATER CONTENT PERCENT
103.2	13.9	102.5	14.3
103.2	14.8	101.2	15.2
101.2	15.4	103.9	15.7
103.5	16.6	105.4	16.5
104.3	16.7	104.8	17.3
107.7	17.9	107.9	18.0
108.1	18.1	107.7	18.3
108.0	18.3	106.7	20.8
104.6	21.6	104.7	21.7
104.6	21.9	104.2	22.5
103.2	22.5		

ID- PP FIELD RUBBER TIRED ROLLER-150 PSI-8 COVERAGES A-6(10)

DRY DENSITY LBS / CU FT	WATER CONTENT PERCENT	DRY DENSITY LBS / CU FT	WATER CONTENT PERCENT
105.1	11.0	104.8	11.2
108.8	11.3	108.7	11.4
108.7	11.7	108.8	11.8
111.8	13.2	111.3	13.3
110.2	13.8	111.0	13.8
111.3	13.8	113.0	14.1
114.8	15.3	115.3	15.3
116.8	15.3	115.3	15.7
112.7	17.1	113.2	17.1
112.8	17.3	113.2	17.5
112.3	17.7	111.2	18.6
109.5	18.8	109.2	19.0
108.7	19.7	107.8	20.0
106.6	20.2	106.5	20.5
105.2	20.8	106.6	21.1
105.3	21.1	105.0	21.1
105.5	21.5		

ID- PP FIELD RUBBER TIRED ROLLER-150 PSI-4 COVERAGES A-6(10)

DRY DENSITY LBS / CU FT	WATER CONTENT PERCENT	DRY DENSITY LBS / CU FT	WATER CONTENT PERCENT
104.8	11.7	105.0	11.7
106.0	12.0	106.4	12.2
105.8	12.2	105.7	12.3
108.4	13.2	108.2	13.2
107.8	13.5	110.7	13.3
110.5	13.5	112.2	13.5
111.2	13.7	110.8	14.2
114.5	14.6	112.5	14.6
112.0	14.6	110.2	14.7
110.2	15.2	112.0	15.2
111.4	15.3	111.7	17.1
111.9	17.1	110.7	17.5
110.3	17.7	110.8	17.8
111.5	17.8	110.1	18.3
110.0	18.7	109.8	18.7
107.0	19.2	107.8	19.7
107.2	20.0	107.2	20.1
106.5	20.2	106.5	20.5
106.0	20.7	105.6	21.0
105.1	20.8	105.0	21.0
104.2	21.2	104.3	21.3

ID- PP FIELD RUBBER TIRED ROLLER-150 PSI-12 COVERAGES A-6(10)

DRY DENSITY LBS / CU FT	WATER CONTENT PERCENT	DRY DENSITY LBS / CU FT	WATER CONTENT PERCENT
107.8	11.2	106.5	11.3
108.2	11.5	104.6	11.6
105.9	11.6	108.3	11.8
108.8	11.9	108.7	12.0
107.2	12.1	109.3	12.5
109.2	12.8	109.9	12.8
115.5	14.1	115.3	14.2
117.4	15.2	116.7	15.3
115.8	15.5	115.3	15.7
114.9	16.1	114.5	16.2
114.3	16.2	114.2	16.3
115.2	16.5	114.5	16.5
113.5	16.8	110.5	16.8
114.2	17.0	113.3	17.1
109.4	18.7	109.9	19.1
109.4	19.1	108.9	19.1
109.4	19.2	110.0	19.7
108.3	19.7	107.7	20.0
107.0	20.0	107.6	20.1
107.5	20.2	107.0	20.3

ID- BBB LAB. 5 LAYERS-10 HAMMER-12 BLOWS PER-18 IN. DROP WITH UU TEST (CONFINING PRESSURE = 0.3 TSF) A-6(10)

DRY DENSITY LBS / CU FT	WATER CONTENT PERCENT	MAX. STRESS PSI
102.5	12.2	5.2
104.5	13.6	5.3
107.4	16.7	4.5
105.3	18.7	3.2
101.7	21.3	2.2

ID- BBB LAB. 5 LAYERS-10 HAMMER-26 BLOWS PER-18 IN. DROP WITH UU TEST (CONFINING PRESSURE = 0.3 TSF) A-6(10)

DRY DENSITY LBS / CU FT	WATER CONTENT PERCENT	MAX. STRESS PSI
107.2	9.5	10.3
112.2	12.6	9.3
111.4	15.5	7.1
108.8	17.5	5.7
105.8	18.9	8.8

ID- BBB LAB. 3 LAYERS-5.5 HAMMER-25 BLOWS PER-12 IN. DROP WITH UU TEST (CONFINING PRESSURE = 0.3 TSF) A-6(10)

DRY DENSITY LBS / CU FT	WATER CONTENT PERCENT	MAX. STRESS PSI
90.7	12.0	2.1
94.5	14.3	2.3
99.5	17.5	2.1
101.0	19.3	1.8
97.3	21.2	1.5
96.0	24.8	1.0

ID- BBB LAB. 5 LAYERS-10 HAMMER-12 BLOWS PER-18 IN. DROP WITH UU TEST (CONFINING PRESSURE = 1.0 TSF) A-6(10)

DRY DENSITY LBS / CU FT	WATER CONTENT PERCENT	MAX. STRESS PSI
104.3	12.0	8.7
105.3	12.8	9.0
108.4	16.3	7.2
104.8	18.8	4.7
102.0	20.7	3.3

ID- BBB LAB. 5 LAYERS-10 HAMMER-26 BLOWS PER-18 IN. DROP WITH UU TEST (CONFINING PRESSURE = 1.0 TSF) A-6(10)

DRY DENSITY LBS / CU FT	WATER CONTENT PERCENT	MAX. STRESS PSI
105.5	9.2	9.3
112.7	12.8	10.7
112.8	15.3	10.2
109.4	17.5	7.2
107.8	18.6	5.8

ID- BBB LAB. 3 LAYERS-5.5 HAMMER-25 BLOWS PER-12 IN. DROP WITH UU TEST (CONFINING PRESSURE = 1.0 TSF) A-6(10)

DRY DENSITY LBS / CU FT	WATER CONTENT PERCENT	MAX. STRESS PSI
94.4	13.9	4.2
109.3	16.7	4.3
109.5	19.1	3.2
108.7	21.5	3.2
96.0	24.5	1.3

ID- BBB LAB. 5 LAYERS-10 HAMMER-12 BLOWS PER-18 IN. DROP A-6(10)
WITH UU TEST (CONFINING PRESSURE = 3.0 TSF)

DRY DENSITY LBS / CU FT	WATER CONTENT PERCENT	MAX. STRESS PSI
103.3	12.1	11.7
107.6	12.7	13.4
108.0	16.3	10.5
101.4	20.2	6.7

ID- BBB LAB. 5 LAYERS-10 HAMMER-26 BLOWS PER-18 IN. DROP A-6(10)
WITH UU TEST (CONFINING PRESSURE = 3.0 TSF)

DRY DENSITY LBS / CU FT	WATER CONTENT PERCENT	MAX. STRESS PSI
106.7	8.8	17.2
112.5	12.8	16.4
112.8	15.1	15.5
108.4	17.3	12.7
106.8	18.7	9.3

ID- BBB LAB. 3 LAYERS-5.5 HAMMER-25 BLOWS PER-12 IN. DROP A-6(10)
WITH UU TEST (CONFINING PRESSURE = 3.0 TSF)

DRY DENSITY LBS / CU FT	WATER CONTENT PERCENT	MAX. STRESS PSI
90.3	11.0	8.8
93.2	13.6	9.1
96.7	16.1	8.4
98.8	18.6	7.2
98.5	20.2	6.7
96.6	23.7	2.6

IL- BBB LAB. 5 LAYERS-10 HAMMER-12 BLOWS PER-18 IN. DROP WITH CORRECTED CBR — A-6(10)

DRY DENSITY LBS / CU FT	WATER CONTENT PERCENT	CORR. CBR PERCENT
95.5	10.3	27.0
98.1	11.7	-0
99.5	12.3	30.0
103.0	16.0	25.0
104.7	17.2	-0
106.8	18.5	8.0
104.4	18.7	-0
103.7	19.3	-0
104.0	19.6	-0
102.9	20.3	-0
102.0	21.5	3.0

ID- BBB LAB. 5 LAYERS-10 HAMMER-26 BLOWS PER-18 IN. DROP WITH CORRECTED CBR — A-6(10)

DRY DENSITY LBS / CU FT	WATER CONTENT PERCENT	CORR. CBR PERCENT
103.0	10.1	47.0
105.7	11.8	-0
107.5	12.7	43.0
109.0	13.7	-0
110.3	14.5	38.0
111.2	15.5	-0
110.8	16.6	15.0
108.8	17.8	-0
107.9	18.7	4.0
106.0	19.5	-0
103.9	20.8	3.0

ID- BBB LAB. 5 LAYERS-10 HAMMER-55 BLOWS PER-18 IN. DROP WITH CORRECTED CBR — A-6(10)

DRY DENSITY LBS / CU FT	WATER CONTENT PERCENT	CORR. CBR PERCENT
109.3	10.3	83.0
113.2	12.3	-0
114.5	13.5	77.0
116.5	14.3	-0
115.7	15.7	23.0
111.5	17.2	-0
109.5	18.0	4.0
107.0	19.0	-0
105.5	20.3	2.0

ID- BBB LAB. 3 LAYERS-5.5 HAMMER-25 BLOWS PER-12 IN. DROP A-6(10)
WITH CORRECTED CBR

DRY DENSITY LBS / CU FT	WATER CONTENT PERCENT	CORR. CBR PERCENT
90.0	10.8	16.0
93.0	12.8	-0
94.5	14.2	15.0
97.7	16.3	-0
99.5	18.0	13.0
100.2	20.2	7.0
99.7	21.3	-0
99.5	22.3	4.0
98.6	23.8	-0

ID- WWW LAB. 5 LAYERS-10 HAMMER-83 BLOWS PER-18 IN. DROP A-6(10)
WITH CORRECTED CBR

DRY DENSITY LBS / CU FT	WATER CONTENT PERCENT	CORR. CBR PERCENT
106.7	11.3	64.0
107.6	12.6	-0
108.8	3.8	52.0
109.5	15.7	39.0
108.3	16.3	27.0
105.2	17.8	7.0
102.0	19.6	4.0

ID- WWW LAB. 5 LAYERS-10 HAMMER-55 BLOWS PER-18 IN. DROP A-6(10)
WITH CORRECTED CBR

DRY DENSITY LBS / CU FT	WATER CONTENT PERCENT	CORR. CBR PERCENT
109.3	10.3	83.0
113.3	2.3	-0
114.4	13.5	77.0
116.5	14.3	-0
115.7	15.7	23.0
111.5	17.2	-0
109.6	18.0	4.0
107.0	19.0	-0
105.5	20.3	2.0

ID- WWW LAB. 5 LAYERS-10 HAMMER-39 BLOWS PER-18 IN. DROP WITH CORRECTED CBR A-6(10)

DRY DENSITY LBS / CU FT	WATER CONTENT PERCENT	CORR. CBR PERCENT
100.7	11.3	36.0
103.2	13.2	-0
105.0	15.1	32.0
106.2	16.9	18.0
101.9	19.2	6.0
99.7	20.7	4.0

ID- WWW LAB. 5 LAYERS-10 HAMMER-26 BLOWS PER-18 IN. DROP WITH CORRECTED CBR A-6(10)

DRY DENSITY LBS / CU FT	WATER CONTENT PERCENT	CORR. CBR PERCENT
103.1	10.1	47.0
107.4	12.7	43.0
109.0	13.7	-0
110.3	14.5	38.0
111.2	15.5	-0
110.7	16.6	15.0
108.7	17.8	-0
107.8	18.7	4.0
106.0	19.5	-0
103.8	20.8	3.0

ID- WWW LAB. 5 LAYERS-10 HAMMER-18 BLOWS PER-18 IN. DROP WITH CORRECTED CBR A-6(10)

DRY DENSITY LBS / CU FT	WATER CONTENT PERCENT	CORR. CBR PERCENT
97.0	11.5	18.0
98.2	4.4	18.0
100.2	16.5	-0
101.3	17.5	16.0
101.2	19.0	9.0

ID- WWW LAB. 5 LAYERS-10 HAMMER-12 BLOWS PER-18 IN. DROP A-6(10)
WITH CORRECTED CBR

DRY DENSITY LBS / CU FT	WATER CONTENT PERCENT	CORR. CBR PERCENT
95.5	10.3	27.0
98.1	11.7	-0
99.6	12.3	31.0
103.1	16.0	25.0
104.7	17.2	-0
106.6	18.5	8.0
104.4	18.7	-0
103.7	19.3	-0
104.0	19.7	-0
102.8	20.3	-0
102.1	21.5	3.0

ID- XXX FIELD SHEEPSFOOT-7 IN SQ FEET-6 PASSES CUBE SAMPLE A-6(10)

DRY DENSITY LBS / CU FT	WATER CONTENT PERCENT	DRY DENSITY LBS / CU FT	WATER CONTENT PERCENT
103.8	11.4	104.0	11.6
104.5	11.8	102.8	11.7
102.0	12.0	103.3	12.3
108.5	12.5	104.3	13.2
102.3	13.2	101.6	13.3
99.4	13.6	100.6	13.6
102.3	13.7	108.0	13.7
104.0	13.9	100.8	14.5
101.7	14.6	100.3	15.2
101.8	17.1	101.2	17.2
103.3	17.3	102.8	17.6
103.7	17.8	102.7	17.9
104.5	18.2	104.2	18.7
104.5	19.2	106.5	19.2
105.3	19.7	103.6	20.2
104.6	20.2	104.5	20.6
104.5	20.8	103.3	20.9
103.2	21.1	104.5	21.2

ID- XXX FIELD SHEEPSFOOT-7 IN SQ FEET-12 PASSES CUBE SAMPLE A-6(10)

DRY DENSITY LBS / CU FT	WATER CONTENT PERCENT	DRY DENSITY LBS / CU FT	WATER CONTENT PERCENT
104.2	10.3	104.6	11.3
103.9	11.7	104.6	11.7
102.3	11.8	103.3	12.0
104.2	12.2	102.9	12.4
103.0	12.7	104.7	12.7
103.0	14.0	104.7	14.3
105.2	14.3	104.8	14.8
105.6	14.8	107.3	14.8
107.7	15.0	105.3	17.3
106.4	17.4	107.3	17.6
105.7	17.8	106.8	18.0
105.4	19.8	104.4	20.7
103.5	20.8	104.3	21.2
103.6	21.3	102.5	21.4
103.7	21.6	102.6	21.9

ID- XXX FIELD SHEEPSFOOT-7 IN SQ FEET-24 PASSES CUBE SAMPLE A-6(10)

DRY DENSITY LBS / CU FT	WATER CONTENT PERCENT	DRY DENSITY LBS / CU FT	WATER CONTENT PERCENT
103.5	12.5	104.7	12.6
101.6	12.8	104.6	12.8
107.3	12.8	105.6	13.3
109.4	15.8	108.5	16.3
109.4	16.4	107.9	16.6
109.4	16.8	108.3	17.2
103.7	20.8	103.7	21.0
104.2	21.2	103.7	21.3
102.8	21.8	99.0	21.8
102.7	22.2		

ID- XXX FIELD SHEEPSFOOT-14 IN SQ FEET- 6 PASSES A-6(10)

DRY DENSITY LBS / CU FT	WATER CONTENT PERCENT	DRY DENSITY LBS / CU FT	WATER CONTENT PERCENT
97.3	12.7	102.5	13.2
102.5	14.0	101.4	14.0
98.6	14.2	100.5	14.3
103.6	14.3	102.3	14.4
103.3	14.7	104.4	14.8
107.7	17.5	104.7	18.8
104.8	19.2	104.7	19.7
102.2	19.9	105.5	20.0
104.8	20.0	104.0	20.0
103.6	20.2	105.5	20.8
103.8	20.8	105.4	21.2
104.7	21.2	103.9	21.2
102.5	21.1	102.0	21.3
103.0	21.5	102.4	21.5

ID- XXX FIELD SHEEPSFOOT-14 IN SQ FEET-12 PASSES A-6(10)

DRY DENSITY LBS / CU FT	WATER CONTENT PERCENT	DRY DENSITY LBS / CU FT	WATER CONTENT PERCENT
102.5	12.1	101.3	12.2
100.8	12.3	103.7	12.3
101.3	12.8	102.7	12.8
104.5	12.8	101.9	13.0
103.5	13.0	105.4	18.7
105.5	19.0	104.4	19.2
105.3	19.3	106.1	19.5
105.0	19.7	104.5	19.7
103.8	19.8	104.3	21.0
105.4	21.1	105.0	21.3
104.3	21.3	103.8	21.5
104.3	21.7	103.7	21.8
103.3	22.3		

ID- XXX FIELD SHEEPSFOOT-14 IN SQ FEET-24 PASSES A-6(10)

DRY DENSITY LBS / CU FT	WATER CONTENT PERCENT	DRY DENSITY LBS / CU FT	WATER CONTENT PERCENT
105.5	11.7	106.5	12.0
103.6	12.2	106.0	12.3
104.5	12.4	105.3	12.6
106.0	13.2	105.5	18.0
105.6	18.3	106.3	18.3
106.3	18.6	105.6	18.7
104.7	18.7	104.8	20.8
104.0	21.4	103.3	21.6
102.8	21.7	103.2	21.8
103.2	22.1	102.3	22.2

ID- XXX LAB. 5 LAYERS-10 HAMMER-55 BLOWS PER-18 IN. DROP A-6(10)
WITH CORRECTED CBR

DRY DENSITY LBS / CU FT	WATER CONTENT PERCENT	CORR. CBR PERCENT
112.4	9.5	111.0
115.5	11.5	110.0
118.2	12.9	73.8
115.7	15.3	17.0
111.0	17.6	5.0

ID- XXX LAB. 5 LAYERS-10 HAMMER-26 BLOWS PER-18 IN. DROP A-6(10)
WITH CORRECTED CBR

DRY DENSITY LBS / CU FT	WATER CONTENT PERCENT	CORR. CBR PERCENT
107.0	11.5	53.0
110.7	13.2	47.0
112.9	15.3	29.0
110.4	17.2	9.0
107.6	19.1	4.0

ID- XXX LAB. 5 LAYERS-10 HAMMER-12 BLOWS PER-18 IN. DROP A-6(10)
WITH CORRECTED CBR

DRY DENSITY LBS / CU FT	WATER CONTENT PERCENT	CORR. CBR PERCENT
102.5	13.8	27.5
105.0	15.0	27.0
107.8	17.0	13.0
106.4	18.9	5.0
104.3	20.8	2.5

ID- YYY LAB. KNEADING-300 PSI A-6(10)

DRY DENSITY LBS / CU FT	WATER CONTENT PERCENT	DRY DENSITY LBS / CU FT	WATER CONTENT PERCENT
111.1	12.6	113.7	14.4
115.2	15.7	113.4	17.4
109.8	19.6		

ID- YYY LAB. KNEADING-200 PSI A-6(10)

DRY DENSITY LBS / CU FT	WATER CONTENT PERCENT	DRY DENSITY LBS / CU FT	WATER CONTENT PERCENT
107.5	12.7	110.5	15.0
112.5	17.0	102.3	21.8

ID- YYY LAB. KNEADING-100 PSI A-6(10)

DRY DENSITY LBS / CU FT	WATER CONTENT PERCENT	DRY DENSITY LBS / CU FT	WATER CONTENT PERCENT
101.5	12.8	106.0	16.0
107.0	19.3	103.1	21.6

ID-CCCC LAB. 3 LAYERS-5.5 LB HAMMER-25 BLOWS PER-12 IN DROP A-6(11)

DRY DENSITY LBS / CU FT	WATER CONTENT PERCENT	DRY DENSITY LBS / CU FT	WATER CONTENT PERCENT
100.0	5.0	100.9	5.0
103.4	5.0	97.8	7.0
102.0	7.0	99.4	7.9
108.0	7.9	100.0	8.4
115.0	9.0	103.8	9.4
103.9	9.9	100.7	10.4
106.4	11.5	101.6	11.9
101.6	12.5	108.8	12.9
118.8	12.9	104.7	13.9
109.0	13.9	106.1	15.0
114.8	15.0	107.9	15.9
113.4	15.9	108.0	16.9
109.0	16.9	111.9	16.9
110.0	17.4	106.0	19.3
105.6	19.9	106.5	19.9
107.0	19.9	101.1	21.9
101.7	21.9	99.8	22.3
97.8	23.9	97.3	24.4

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APPENDIX B

INDIANA STATE HIGHWAY COMMISSION

FILE DATA

CATEGORY TITLE Project ST-F-78(63) Soil xxxx*

Roller - Rascal Passes 5

DRY DENSITY LBS / CU FT	WATER CONTENT PERCENT	DRY DENSITY LBS / CU FT	WATER CONTENT PERCENT
109.2	15.0	111.8	15.1
112.9	14.7	112.2	13.0
111.7	14.1	110.9	12.1
109.9	12.2	112.1	10.8

CATEGORY TITLE Project ST-F-78(63) Soil xxxx

Roller - Rascal Passes 6

DRY DENSITY LBS / CU FT	WATER CONTENT PERCENT	DRY DENSITY LBS / CU FT	WATER CONTENT PERCENT
107.2	14.7	112.2	14.7
110.6	15.0	111.5	14.8
110.9	15.0		

CATEGORY TITLE Project ST-F-78(63) Soil xxxx

Roller - FWD - Sheepsfoot Passes 4

DRY DENSITY LBS / CU FT	WATER CONTENT PERCENT	DRY DENSITY LBS / CU FT	WATER CONTENT PERCENT
105.9	16.5	111.6	11.9
108.6	13.5	107.2	16.0
106.0	16.5	106.0	16.0
106.0	16.8	105.7	16.8
107.5	17.0	107.0	16.5
107.6	17.0	108.4	16.0
107.6	16.9	107.4	17.1
106.4	16.9	107.7	16.4
108.7	16.6		

*Note xxxx denotes no classification of soil type obtained.

CATEGORY TITLE Project I-64-3(40) Soil xxxx

Roller - Segmented Pad Passes 4

DRY DENSITY LBS / CU FT	WATER CONTENT PERCENT	DRY DENSITY LBS / CU FT	WATER CONTENT PERCENT
108.1	12.3	107.3	12.3
116.5	12.3	119.7	12.3
109.7	14.9	110.1	14.9
114.7	13.0		

CATEGORY TITLE Project I-64-3(40) Soil xxxx

Roller - Segmented Pad Passes 5

DRY DENSITY LBS / CU FT	WATER CONTENT PERCENT	DRY DENSITY LBS / CU FT	WATER CONTENT PERCENT
103.9	11.8	102.9	12.5
106.2	14.9	111.8	14.2
112.5	14.2	114.6	14.2
117.8	12.3	114.2	12.6
112.6	12.6	112.3	12.6
110.6	13.6	115.3	16.3
111.7	16.3	111.0	16.3
109.5	16.3	110.4	16.9
107.1	20.4	105.6	16.9
105.6	16.9	104.7	16.9
107.1	16.3	106.6	16.3

CATEGORY TITLE Project I-64-3(40) Soil A-7-6(13)

Roller - Segmented Pad Passes 8 - 10

DRY DENSITY LBS / CU FT	WATER CONTENT PERCENT	DRY DENSITY LBS / CU FT	WATER CONTENT PERCENT
111.1	11.7	107.5	14.9
107.6	9.3	107.7	11.0
107.6	12.5		

CATEGORY TITLE

Project I-64-3(40)   Soil A-6(9)

Roller - Segmented Pad   Passes 5

DRY DENSITY LBS / CU FT	WATER CONTENT PERCENT	DRY DENSITY LBS / CU FT	WATER CONTENT PERCENT
101.8	18.3	106.9	18.3
101.5	20.4	104.1	20.4
114.9	14.2	106.3	16.3
104.3	18.3	105.2	16.3

CATEGORY TITLE

Project I-64-3(40)   Soil A-7-6(13)

Roller - Segmented Pad   Passes 4

DRY DENSITY LBS / CU FT	WATER CONTENT PERCENT	DRY DENSITY LBS / CU FT	WATER CONTENT PERCENT
104.8	14.5	103.3	14.9
112.9	11.7	103.7	15.7
119.5	10.7	98.6	17.6
99.8	16.9		

CATEGORY TITLE

Project I-64-3(40)   Soil A-7-6(13)

Roller - Segmented Pad   Passes 5

DRY DENSITY LBS / CU FT	WATER CONTENT PERCENT	DRY DENSITY LBS / CU FT	WATER CONTENT PERCENT
103.4	14.9	110.4	17.6
109.5	14.2	109.9	14.2
113.0	14.2	112.5	14.9
107.7	14.9	112.5	14.9
110.4	14.1	111.6	14.1
113.1	14.1	112.0	14.1
108.3	14.2	111.6	14.2
107.7	14.2	109.6	14.2
109.9	14.2	113.9	14.7
111.1	14.7	109.9	14.7
110.3	14.7	114.1	14.0
111.8	14.0	111.3	14.0
112.5	14.0	110.2	14.0
110.9	14.0	108.3	14.2
111.6	14.2	107.7	14.2
109.6	14.2	109.9	14.2

CATEGORY TITLE   Project I-64-3(40)   Soil xxxx

Roller - Segmented Pad   Passes 4 - 6

DRY DENSITY LBS / CU FT	WATER CONTENT PERCENT	DRY DENSITY LBS / CU FT	WATER CONTENT PERCENT
112.9	11.7	110.7	11.7
110.7	11.7	113.8	11.7
113.2	11.7	107.8	11.7
109.7	11.7	113.4	11.7
119.1	11.7		

CATEGORY TITLE   Project I-64-3(40)   Soil xxxx

Roller - Segmented Pad   Passes 6

DRY DENSITY LBS / CU FT	WATER CONTENT PERCENT	DRY DENSITY LBS / CU FT	WATER CONTENT PERCENT
113.8	12.3	116.0	13.0
110.3	11.8	109.9	14.9
108.3	14.9	112.0	14.9

CATEGORY TITLE   Project I-64-3(40)   Soil xxxx

Roller - Segmented Pad   Passes 8

DRY DENSITY LBS / CU FT	WATER CONTENT PERCENT	DRY DENSITY LBS / CU FT	WATER CONTENT PERCENT
115.9	14.7	112.9	11.7
113.6	15.7	113.2	8.9
116.6	11.3	116.3	10.5
115.2	13.4	116.8	13.0

CATEGORY TITLE Project I-64-3(40) Soil A-7-6(13)

Roller - Segmented Pad Passes 4 - 6

DRY DENSITY LBS / CU FT	WATER CONTENT PERCENT	DRY DENSITY LBS / CU FT	WATER CONTENT PERCENT
108.8	14.6	104.4	14.6
104.4	15.6	103.3	15.6
105.5	15.6	104.8	15.6
106.2	15.6	106.3	15.6
107.4	15.6	110.6	15.6
105.7	14.2	107.1	14.2
106.2	14.2	111.6	14.2
103.9	15.6	106.7	15.6
108.9	16.3	108.9	16.3
109.5	16.3	105.2	15.6
105.2	16.3	109.3	16.3
104.7	16.3	105.5	16.2
103.4	16.3	114.1	14.9

CATEGORY TITLE Project I-64-3(40) Soil A-7-6(13)

Roller - Segmented Pad Passes 10

DRY DENSITY LBS / CU FT	WATER CONTENT PERCENT	DRY DENSITY LBS / CU FT	WATER CONTENT PERCENT
111.1	11.7	107.5	14.9
107.6	9.3	107.7	11.0
107.6	12.5		

CATEGORY TITLE Project I-64-3(40) Soil A-4(8)

Roller - Segmented Pad Passes 4 - 6

DRY DENSITY LBS / CU FT	WATER CONTENT PERCENT	DRY DENSITY LBS / CU FT	WATER CONTENT PERCENT
109.8	15.6	110.4	15.6
109.3	16.3	108.1	16.3
110.7	13.0	112.8	13.0
110.8	13.0	112.5	13.6
110.4	13.6	112.5	13.6
110.4	13.6	114.1	12.3
111.5	12.3		

CATEGORY TITLE Project I-64-3(40) Soil A-6(9)

Roller - Segmented Pad Passes - 4

DRY DENSITY LBS / CU FT	WATER CONTENT PERCENT	DRY DENSITY LBS / CU FT	WATER CONTENT PERCENT
101.2	18.3	96.7	20.4
102.3	18.3	102.3	16.3

CATEGORY TITLE Project I-64-3(40) Soil A-7-6(13)

Roller - Segmented Pad Passes - 6

DRY DENSITY LBS / CU FT	WATER CONTENT PERCENT	DRY DENSITY LBS / CU FT	WATER CONTENT PERCENT
108.3	14.6	109.5	17.4
111.6	17.7	107.3	16.9
108.6	16.9		

CATEGORY TITLE Project I-64-3(40) Soil A-7-6(13)

Roller - Segmented Pad Passes - 5

DRY DENSITY LBS / CU FT	WATER CONTENT PERCENT	DRY DENSITY LBS / CU FT	WATER CONTENT PERCENT
108.3	16.3	106.6	14.9
103.6	17.6	108.9	13.6
105.4	15.7	108.5	14.5
109.8	14.3	100.2	19.0
104.5	20.4	106.1	20.4

CATEGORY TITLE — Project I-64-3(40). — Soil xxxx

Roller - Segmented Pad — Passes 5

DRY DENSITY LBS / CU FT	WATER CONTENT PERCENT	DRY DENSITY LBS / CU FT	WATER CONTENT PERCENT
115.8	14.9	115.2	14.9
112.4	14.9	115.6	13.0
117.4	13.0	113.9	12.3
119.2	12.3	120.3	12.3
113.4	12.3	115.8	12.3
112.6	12.3	113.1	12.3
115.4	12.3	117.0	13.6
109.7	13.6	118.6	12.3

CATEGORY TITLE — Project I-64-3(40) — Soil A-7-6(13)

Roller - Segmented Pad — Passes 8

DRY DENSITY LBS / CU FT	WATER CONTENT PERCENT	DRY DENSITY LBS / CU FT	WATER CONTENT PERCENT
107.0	14.2	111.1	9.9
111.9	15.4	110.7	17.4
109.6	16.0	110.8	16.5
107.0	16.4	109.9	16.8

CATEGORY TITLE — Project I-64-2(13) — Soil A-6(12)

Roller - FWD - Sheepsfoot — Passes 3

DRY DENSITY LBS / CU FT	WATER CONTENT PERCENT	DRY DENSITY LBS / CU FT	WATER CONTENT PERCENT
116.5	15.3	115.1	15.3
115.1	15.3	114.6	15.3
112.3	15.3	113.1	15.3

CATEGORY TITLE Project I-64-2(13) Soil A-7-6(15)

Roller - Sheepsfoot Passes 6

DRY DENSITY LBS / CU FT	WATER CONTENT PERCENT	DRY DENSITY LBS / CU FT	WATER CONTENT PERCENT
107.0	20.0	99.7	20.0
106.2	20.5	109.0	18.3
108.5	18.3	114.4	16.0
113.2	12.5	113.0	13.8

CATEGORY TITLE Project I-64-2(19) Soil A-6(11)

Roller - Sheepsfoot Passes 3

DRY DENSITY LBS / CU FT	WATER CONTENT PERCENT	DRY DENSITY LBS / CU FT	WATER CONTENT PERCENT
110.9	16.0	106.4	19.0
105.9	16.0	109.8	18.0
112.9	15.2	103.9	13.0
98.9	16.0	115.9	17.0
100.6	14.1	106.2	11.0
108.4	15.2	116.7	19.0

CATEGORY TITLE Project I-64-2(19) Soil A-6(8)

Roller - Sheepsfoot Passes 3

DRY DENSITY LBS / CU FT	WATER CONTENT PERCENT	DRY DENSITY LBS / CU FT	WATER CONTENT PERCENT
109.8	17.0	107.7	17.0
110.9	16.0	109.3	16.7
110.9	16.5	111.6	16.5
111.3	16.5	105.7	19.5
111. 2	16.5		

CATEGORY TITLE   Project I-64-2(13)   Soil A-7-6(15)

Roller - Sheepsfoot   Passes - 3

DRY DENSITY LBS / CU FT	WATER CONTENT PERCENT	DRY DENSITY LBS / CU FT	WATER CONTENT PERCENT
108.0	21.5	109.2	18.4
105.9	20.0	104.0	20.0
119.2	15.5	116.7	17.0
106.2	20.0	95.6	20.0
103.5	22.4	107.5	16.0
111.8	18.4	106.0	18.4
107.5	18.2	102.8	20.0
98.6	24.0	103.3	19.2
108.9	15.6	94.8	20.5
105.5	20.5	109.5	20.5
105.0	17.6	112.2	17.6
103.5	17.6	104.7	17.6
97.4	18.3	108.9	16.0
109.9	16.0	106.6	16.0
111.5	17.0	108.4	17.0
109.2	17.0	108.5	17.0
108.1	15.5	113.3	15.5
109.1	14.0	102.3	23.5
108.0	16.0	105.0	16.0
105.2	16.0	105.1	12.5
112.3	12.5	106.0	17.9
107.2	16.0	110.4	16.0
114.8	16.0	114.6	15.0
113.4	12.5	108.9	15.0
106.4	15.0	111.4	19.5
100.8	21.5	107.0	20.7
106.5	20.7	106.9	20.7
103.8	19.7	107.2	17.0
104.6	18.2	102.5	18.2

CATEGORY TITLE   Project I-64-2(13)   Soil A-7-6(15)

Roller - FWD - Sheepsfoot   Passes 4

DRY DENSITY LBS / CU FT	WATER CONTENT PERCENT	DRY DENSITY LBS / CU FT	WATER CONTENT PERCENT
108.7	17.0	104.6	17.0
111.9	12.0	114.3	12.2

CATEGORY TITLE Project I-64-2(13) Soil A-7-6(20)

Roller - FWD - Sheepsfoot Passes 3

DRY DENSITY LBS / CU FT	WATER CONTENT PERCENT	DRY DENSITY LBS / CU FT	WATER CONTENT PERCENT
99.6	16.0	102.8	16.0
107.2	16.0	106.6	16.0
107.2	19.0	117.3	14.0
111.1	14.0	101.7	19.0
112.0	19.0	109.7	19.0
106.0	19.0	110.0	19.0
109.3	18.2		

CATEGORY TITLE Project I-64-2(13) Soil A-7-6(15)

Roller - FWD - Sheepsfoot Passes 3

DRY DENSITY LBS / CU FT	WATER CONTENT PERCENT	DRY DENSITY LBS / CU FT	WATER CONTENT PERCENT
105.4	20.0	105.0	18.0
110.6	18.0	110.8	16.0
105.5	18.3	102.7	18.3
108.4	16.1	108.5	16.0
110.3	16.0	105.5	18.1
105.9	13.1	111.6	17.0
107.9	17.0		

CATEGORY TITLE Project I-64-2(13) Soil A-7-6(20)

Roller - Sheepsfoot Passes 3

DRY DENSITY LBS / CU FT	WATER CONTENT PERCENT	DRY DENSITY LBS / CU FT	WATER CONTENT PERCENT
115.2	17.0	112.5	17.0
113.8	17.0	107.5	17.0
104.2	16.0	106.9	18.0
111.2	18.0	103.7	0
107.7	16.5	111.9	17.0
106.3	19.0	118.5	15.5
108.2	20.0	104.6	19.0
102.8	21.5	105.2	20.0
104.7	18.5	103.7	18.0
97.6	18.5	116.4	11.0
106.9	18.0	105.9	16.0
112.6	15.8	112.0	15.8

CATEGORY TITLE — Project I-64-2(13) — Soil A-6(12)

Roller - Sheepsfoot — Passes 3

DRY DENSITY LBS / CU FT	WATER CONTENT PERCENT	DRY DENSITY LBS / CU FT	WATER CONTENT PERCENT
113.8	16.5	111.6	22.0
113.2	19.0	96.1	20.3
118.6	13.6	118.8	14.3
112.2	14.5	117.1	14.3
111.5	14.3	112.9	18.1
111.9	12.6	111.4	12.0
122.5	12.0	110.9	17.0
112.1	16.0	113.2	12.0
119.0	15.5	113.8	15.5
111.6	15.5	117.6	14.5
107.1	14.5	110.6	14.5
117.4	12.5	107.5	17.5
102.5	17.5	108.4	15.0
106.1	18.0	109.9	16.5
113.9	15.5	111.1	15.5
107.4	15.5	113.2	14.0
106.2	16.5	108.4	18.0

CATEGORY TITLE — Project I-64-2(13) — Soil A-7-6(15)

Roller - Sheepsfoot — Passes 4

DRY DENSITY LBS / CU FT	WATER CONTENT PERCENT	DRY DENSITY LBS / CU FT	WATER CONTENT PERCENT
109.3	20.0	98.0	20.0
101.6	20.0	113.2	17.0
98.2	16.0	100.3	18.5
110.2	18.5	103.2	16.0
109.3	14.0	111.4	14.0
109.5	15.0	115.2	15.0
112.2	18.0	112.4	15.0

CATEGORY TITLE — Project ST-F-78(60) — Soil A-6(11)

Roller - Sheepsfoot — Passes - 9

DRY DENSITY LBS / CU FT	WATER CONTENT PERCENT	DRY DENSITY LBS / CU FT	WATER CONTENT PERCENT
104.6	19.8	110.4	18.0
107.3	18.0	107.5	18.0
107.6	17.0	109.1	16.2
103.8	19.5		

CATEGORY TITLE Project ST-F-78(60) Soil A-6(11)

Roller - Vibratory Passes - 5

DRY DENSITY LBS / CU FT	WATER CONTENT PERCENT	DRY DENSITY LBS / CU FT	WATER CONTENT PERCENT
116.8	13.0	119.8	7.6
116.6	5.0	114.2	15.8
115.7	15.0	102.6	10.5
118.1	9.8	116.8	13.8
116.6	11.0	110.8	13.6
108.9	16.3	112.1	15.2
113.3	14.9	111.6	15.0
116.1	13.5	114.7	15.6

CATEGORY TITLE Project ST-F-78(60) Soil A-6(7)

Roller - Vibratory Passes - 5

DRY DENSITY LBS / CU FT	WATER CONTENT PERCENT	DRY DENSITY LBS / CU FT	WATER CONTENT PERCENT
108.7	17.0	106.4	17.5
108.0	16.5	108.4	15.9
112.6	15.1	111.4	11.0
109.9	13.0	113.1	9.4
114.1	10.4	115.2	6.7
112.5	10.6	111.7	9.0
102.7	8.7	111.0	14.3
110.9	11.0	113.1	8.0
115.5	11.0	114.6	7.2
113.5	14.2		

CATEGORY TITLE Project ST-F-78(60) Soil A-6(11)

Roller - Vibratory Passes - 4

DRY DENSITY LBS / CU FT	WATER CONTENT PERCENT	DRY DENSITY LBS / CU FT	WATER CONTENT PERCENT
114.1	16.0	111.9	16.5
110.5	11.0	113.0	15.0

CATEGORY TITLE Project ST-F-78(60) Soil A-6(11)

Roller - FWD - Sheepsfoot Passes 5

DRY DENSITY LBS / CU FT	WATER CONTENT PERCENT	DRY DENSITY LBS / CU FT	WATER CONTENT PERCENT
104.0	16.5	106.5	16.1
107.0	15.8	109.7	14.5
113.3	13.9	110.8	15.0
114.8	17.3	104.9	18.0
113.0	17.3	108.9	16.8
108.2	17.0	101.9	18.0

CATEGORY TITLE Project ST-F-78(60) Soil A-6(11)

Roller - FWD - Sheepsfoot Passes - 6

DRY DENSITY LBS / CU FT	WATER CONTENT PERCENT	DRY DENSITY LBS / CU FT	WATER CONTENT PERCENT
101.7	20.0	101.4	21.0
105.2	15.5	105.1	17.1
105.2	16.4	104.8	17.2
107.[illegible]	16.6	105.4	16.5
102.[illegible]	20.0	106.0	21.0
105.5	18.0		

CATEGORY TITLE Project ST-F-78(60) Soil A-6(10)

Roller - Sheepsfoot Passes - 8

DRY DENSITY LBS / CU FT	WATER CONTENT PERCENT	DRY DENSITY LBS / CU FT	WATER CONTENT PERCENT
100.3	21.0	100.7	21.0
112.5	20.0	99.[illegible]	21.0
101.0	20.0	102.8	19.5
87.8	21.0	98.2	20.4
104.2	20.2	104.9	21.0

CATEGORY TITLE Project ST-F-78(60) Soil A-6(9)

Roller - Sheetsfoot Passes - 6

DRY DENSITY LBS / CU FT	WATER CONTENT PERCENT	DRY DENSITY LBS / CU FT	WATER CONTENT PERCENT
106.7	21.5	102.1	20.0
106.5	20.5	105.3	18.0
107.9	18.0	99.8	21.5
103.5	20.2	102.1	19.0
106.5	17.0	105.0	17.5
106.2	17.0	106.3	17.5

CATEGORY TITLE Project ST-F-78(60) Soil A-6(11)

Roller - Sheepsfoot Passes - 11

DRY DENSITY LBS / CU FT	WATER CONTENT PERCENT	DRY DENSITY LBS / CU FT	WATER CONTENT PERCENT
105.[illegible]	19.0	103.7	19.8
104.[illegible]	20.3	105.6	20.1
105.[illegible]	19.6	100.7	21.0
104.7	21.9	104.5	20.0
100.7	20.4		

CATEGORY TITLE Project ST-F-78(60) Soil A-6(11)

Roller - Sheepsfoot Passes - 10

DRY DENSITY LBS / CU FT	WATER CONTENT PERCENT	DRY DENSITY LBS / CU FT	WATER CONTENT PERCENT
105.6	18.1	103.4	19.5
105.5	20.0	101.7	21.0
116.5	16.0	110.6	15.5
100.8	21.0	100.2	21.9
100.2	21.2		

CATEGORY TITLE | Project ST-F-78(60) | Soil A-4(8)

Roller - Vibratory | Passes - 6

DRY DENSITY LBS / CU FT	WATER CONTENT PERCENT	DRY DENSITY LBS / CU FT	WATER CONTENT PERCENT
109.5	17.5	112.3	15.0
110.[illegible]	1[illegible].6	112.5	1[illegible].3
11[illegible].[illegible]	8.5	112.2	12.2
114.9	12.3	113.2	15.3
116.7	12.0	110.2	11.7
112.[illegible]	11.4	109.7	11.8
11[illegible].9	15.1	116.9	1[illegible].6
11[illegible].[illegible]	12.2		

CATEGORY TITLE | Project ST-F-78(60) | Soil A-6-(7)

Roller - FWD - Sheepsfoot | Passes 7

DRY DENSITY LBS / CU FT	WATER CONTENT PERCENT	DRY DENSITY LBS / CU FT	WATER CONTENT PERCENT
107.9	21.[illegible]	108.6	1[illegible].0
102.1	2[illegible].[illegible]	101.[illegible]	20.0
104.9	1[illegible].[illegible]	110.3	20.0
108.0	19.[illegible]	107.8	17.0
106.9	1[illegible].1	105.8	16.5
108.5	17.0	105.5	17.6
109.2	1[illegible].[illegible]	105.4	1[illegible].7
107.8	17.[illegible]	108.5	1[illegible].5
107.2	17.1	108.[illegible]	1[illegible].5
109.9	17.2	107.5	16.0
105.3	1[illegible].[illegible]	110.2	17.1
104.6	1[illegible].[illegible]	111.8	17.5
105.4	1[illegible].[illegible]	108.6	17.0

CATEGORY TITLE | Project ST-F-78(60) | Soil A-6(11)

Roller - Sheepsfoot | Passes - 8

DRY DENSITY LBS / CU FT	WATER CONTENT PERCENT	DRY DENSITY LBS / CU FT	WATER CONTENT PERCENT
104.1	19.[illegible]	106.9	19.5
104.3	20.0	104.7	19.5
103.9	21.0	103.2	21.9
105.8	19.0	103.3	20.0
104.6	19.5	102.7	21.0
105.7	19.0	104.8	19.5
104.0	19.1	107.7	17.5
100.8	23.4		

CATEGORY TITLE — Project ST-F-78(60) — Soil A-6(10)

Roller - Sheepsfoot — Passes - 7

DRY DENSITY LBS / CU FT	WATER CONTENT PERCENT	DRY DENSITY LBS / CU FT	WATER CONTENT PERCENT
100.9	20.3	100.2	20.0
106.4	19.5	99.2	21.0

CATEGORY TITLE — Project ST-F-78(60) — Soil A-6(10)

Roller - Vibratory — Passes - 5

DRY DENSITY LBS / CU FT	WATER CONTENT PERCENT	DRY DENSITY LBS / CU FT	WATER CONTENT PERCENT
110.4	11.7	108.9	[illegible]
105.2	11.7	104.8	7.6

CATEGORY TITLE — Project ST-F-78(60) — Soil A-6(9)

Roller - Sheepsfoot — Passes - 7

DRY DENSITY LBS / CU FT	WATER CONTENT PERCENT	DRY DENSITY LBS / CU FT	WATER CONTENT PERCENT
110.8	16.1	105.0	16.4
105.0	19.0	98.2	26.5
102.[illegible]	20.0	103.8	19.5
101.6	21.0	103.4	20.0

CATEGORY TITLE Project ST-F-78(60) Soil A-6(7)

Roller - FWD - Sheepsfoot Passes 6

DRY DENSITY LBS / CU FT	WATER CONTENT PERCENT	DRY DENSITY LBS / CU FT	WATER CONTENT PERCENT
104.9	19.3	103.0	20.0
103.6	19.0	104.[illegible]	17.5
100.7	17.8	103.9	17.0
105.8	17.[illegible]	107.1	16.8
105.7	17.[illegible]	105.5	16.8
106.3	18.0	113.2	16.1

APPENDIX C

LABORATORY

TEST PROCEDURE

OUTLINE

LABORATORY TEST PROCEDURE

Sample Preparation

1. Weigh out dry soil passing No. 4 sieve.

   5 lbs. (SP)*

   3 lbs. (HM)**

2. Prepare required water for desired percent water content by using appropriate mixing chart.

3. Using a hand atomizer and hand mixing, uniformly blend the water into the soil batch.

4. Enclose the batch in a polyvinylchloride bag and place inside of humidity barrel. After curing overnight the batch is ready to compact.

Compaction

1. Remix thoroughly by hand for a minimum of 5 minutes.

2. Take representative moisture content sample from batch.

3. Compact the sample and record data; (SP) according to ASTM D-698-70 Method A with the following exceptions;

   1) A silicon lubricated, split mold was used to allow the sample to be extruded with minimum disturbance.

   2) This mold was micrometered and the actual volume was used in the density determination.

   3) The water content was taken immediately before compaction.

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* (SP)-indicates for Standard Proctor only

**(HM)-indicates for Harvard Miniature only

4) Note 1 of the procedure was followed since each data sample was saved for further sampling.

(HM) using procedure as outlined under "Suggested Method of Test For Moisture-Density Relations of Soils Using Harvard Compaction Apparatus", Procedures for Testing Soils, ASTM, Fourth Edition, December, 1964 with the following exception:

1. Mold was lubricated with silicon to aid in sample ejection.

Preparation of Unconfined Samples

(SP) 1. Remove sample from split mold and place in quartering jig.

2. Careful quarter sample with band saw.

3. Remove each quarter and trim on hand lathe to approximately 1.4 inch diameter.

4. Trim length of new samples to approximate ratio of 2:1 of length to diameter.

5. Measure diameter length and weight of sample.

6. Place in a non-vented polyvinylchloride bag with appropriate labels and then place bag in humidifier in the constant temperature room.

(HM) 1. Extrude sample from mold.

2. Measure diameter and length of sample

3. Remainder same as for (SP).

Sample Testing

1. After a sample has remained in the humidifier for 5 days, remove the sample.

2. Re-measure sample diameter length and weight.
3. Set corresponding calibration dials for the geometric sample measurements.
4. Center sample on loading frame using top and bottom plattens.
5. Preload sample to 1/2 psi as a seating load.
6. Zero plotter and engage constant rate motor.
7. When failure peak or 20 percent strain is observed stop test and remove sample.
8. The entire sample is used for a water content determination.
9. After the water content is determined, the sample is labeled and saved for later reference.

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